

VOLUME I, BOOK 1
FINAL REPORT

ENERGY SAVINGS OPPORTUNITY SURVEY (ESOS)

WHITE SANDS MISSILE RANGE
NEW MEXICO

Prepared for

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FORT WORTH DISTRICT, CORPS OF ENGINEERS
FORT WORTH, TEXAS

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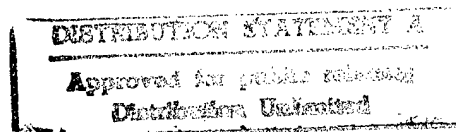
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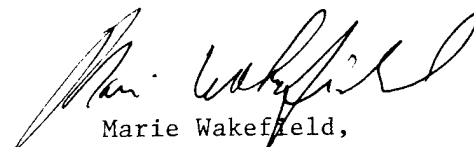


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TABLE OF CONTENTS

(Volume I, Book 1)

<u>Section</u>	<u>Page</u>
LIST OF ABBREVIATIONS	ix
EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION	
1.1 Authority	1-1
1.2 Purpose	1-1
1.3 Scope of Work	1-1
1.4 Organization of the Report	1-2
1.5 Methodology	1-3
1.5.1 Survey	1-3
1.5.2 Analysis	1-3
1.5.3 Project Documentation	1-4
1.5.4 Reporting	1-4
1.6 Results of Previous Studies	1-4
1.7 Accomplishments Under This Study	1-4
1.8 Prefinal Report	1-5
1.9 Final Report	1-5
2.0 HISTORICAL ENERGY CONSUMPTION	
2.1 General	2-1
2.2 Energy Consumption By Type	2-1
2.3 1985 Energy Consumption and the Goal for FY2000	2-3
3.0 EVALUATION OF GENERAL ENERGY CONSERVATION OPPORTUNITIES	
3.1 General	3-1
3.2 ECO #2: Add Roof Insulation	3-2
3.3 ECO #4: Lower Ceiling	3-3
3.4 ECO #7: Install Air Curtains	3-4
3.5 ECO #9: Replace Windows with Energy Efficient Windows	3-5
3.6 ECO #10: Install Instantaneous Point-of-Use Water Heaters	3-7
3.7 ECOs #12 & 13: Replace Existing Light Fixtures with More Efficient Equipment	3-10
3.8 ECO #17: Replace Existing Gas-Fired Heating Equipment with Gas-Fired Infrared or Radiant Heaters in High Bay Areas	3-12
3.9 ECOs #19 & 20: Install Thermostatically Controlled Radiator/Convactor Valves	3-14
3.10 ECO #29: Install a Steam Booster Heater on the Dishwasher in Building P1330	3-16
3.11 ECO #30: Install a Boiler for Summer Hot Water Heating in Building P236, Gymnasium	3-17
3.12 Summary of General ECO Evaluations	3-17
3.13 Summary of Nonapplicable ECOs	3-22

TABLE OF CONTENTS (Continued)

(Volume I, Book 1)

<u>Section</u>	<u>Page</u>
4.0 EVALUATION OF ECOs FOR BUILDING P300	
4.1 General	4-1
4.2 Discussion of ECOs	4-2
4.2.1 Lighting Systems	4-2
4.2.2 Waste Heat	4-2
4.2.3 Ventilation and Economizers	4-2
4.2.4 Demand Side Management	4-3
4.2.5 Conversion to Variable Volume Air Systems	4-3
4.2.6 Consolidated Chilled Water Plant	4-3
4.2.7 Contractor-Identified ECOs	4-4
4.3 Operational Practices - HVAC	4-4
4.4 Method of Analysis of Applicable ECOs	4-4
4.5 ECO: Improved Lighting Fixture Efficiency	4-4
4.6 ECO: Reduced Lighting Levels	4-5
4.7 ECO: Waste Heat Recovery	4-5
4.8 ECO: Dry Bulb Economizers	4-6
4.9 ECO: Reduced Outdoor Air Quantities	4-8
4.10 ECO: Thermal Storage	4-8
4.11 ECO: Variable Air Volume	4-9
4.12 ECO: Replace Existing Air-Cooled Chillers with Water-Cooled Chillers	4-11
4.13 ECO: Summary of Results	4-12
4.14 Recommendations	4-13
4.15 Evaluation of the Proposed Modified Configuration for P300	4-13
5.0 BUILDING ENERGY SURVEYS	
5.1 General	5-1
5.2 Building P21140, Temperature Test Facility	5-1
5.2.1 Description of Existing Conditions	5-1
5.2.2 Applicable ECOs	5-2
5.2.3 Method of Analysis	5-2
5.2.4 Results	5-2
5.2.5 Conclusion	5-3
5.3 Building P21695, SWAB	5-3
5.3.1 Description of Existing Conditions	5-3
5.3.2 Applicable ECOs	5-4
5.3.3 Method of Analysis	5-4
5.3.4 Results	5-4
5.3.5 Conclusions	5-5

TABLE OF CONTENTS (Continued) (Volume I, Book 1)

<u>Section</u>	<u>Page</u>
5.4 Building 24072, Helicopter Drone Maintenance Facility	5-5
5.4.1 Description of Existing Conditions	5-5
5.4.2 Applicable ECOs	5-6
5.4.3 Method of Analysis	5-6
5.4.4 Results	5-7
5.4.5 Conclusions	5-8
6.0 ENERGY STUDIES FOR LAUNCH COMPLEX 38	
6.1 General	6-1
6.2 Historical Background	6-3
6.3 Description of Existing Conditions	6-3
6.4 Concept Design Alternatives	6-17
6.5 Conclusions and Recommendations	6-20
7.0 CONTRACTOR-IDENTIFIED ECOs	
7.1 General	7-1
7.2 Building P23640 (Launch Complex 38)	7-1
7.2.1 Description of Existing Conditions	7-1
7.2.2 Applicable ECOs	7-2
7.2.3 Results	7-2
7.2.4 Conclusions	7-3
7.3 Building P23642 (Launch Complex 38)	7-3
7.3.1 Description of Existing Conditions	7-3
7.3.2 Applicable ECOs	7-4
7.3.3 Results	7-4
7.3.4 Conclusions	7-5
7.4 Recommendations	7-5
8.0 DEMAND LIMITING MEASURES	
8.1 General	8-1
8.2 Historical Electrical Demand Data	8-3
8.3 Analysis	8-8
8.3.1 General	8-8
8.3.2 Opportunities to Reduce Constant Loads	8-9
8.4 Feasibility Study of a Consolidated Chilled Water Plant to Serve the Tech Area	8-10
8.4.1 General	8-10
8.4.2 Alt. #1	8-15
8.4.3 Alt. #2	8-16
8.4.4 Alt. #3	8-18
8.4.5 Alt. #4	8-20

TABLE OF CONTENTS (Concluded)
(Volume I, Book 1)

<u>Section</u>	<u>Page</u>
8.5 Summary of Tech Area Chilled Water Plant Study	8-21
8.6 Conclusions and Recommendations	8-22
9.0 SUMMARY OF RESULTS AND RECOMMENDATIONS	
9.1 General ECOs	9-1
9.2 Building P300: Range Control	9-6
9.3 Building Energy Surveys	9-7
9.4 Launch Complex 38	9-9
9.5 Contractor-Identified ECOs	9-10
9.6 Demand Side Management	9-11
9.7 Consolidated Chilled Water Plant to Serve the Tech Area	9-13
10.0 SUMMARY OF RECOMMENDED ENERGY RETROFIT PROJECTS	

APPENDICES

A	Scope of Work, Scope of Work Requirements, Confirmation Notices
B	Trane TRACE 600 Program Description
C	Program Documentation Support Data
D	ECO Back-Up Data (Volume I, Book 2)

LIST OF TABLES

<u>Table</u>	<u>Page</u>
ES-1	ECOs to be Evaluated for Designated Buildings ES-3
ES-2	Recommended General ECOs ES-4
ES-3	Nonrecommended General ECOs ES-5
ES-4	Recommended ECOs, P300 ES-7
ES-5	Nonrecommended ECOs, P300 ES-8
ES-6	Baseline Energy Data ES-8
ES-7	Recommended ECOs, P21140, P21695, P24072 ES-9
ES-8	Nonrecommended ECOs, P21140, P21695, P24072 ES-10
ES-9	Summary of ECOs, LC38 ES-11
ES-10	Recommended ECOs, P23640, P23642 ES-12
ES-11	Nonrecommended ECOs, Tech Area ES-14
ES-12	Data Summary for Energy Projects ES-16
2-1	Electrical Energy Consumption and Cost Data 2-1
2-2	Natural Gas Consumption and Cost Data 2-2
2-3	Natural Gas Consumption and Cost Data (Effective February, 1992) 2-3
3-1	ECOs to be Evaluated for Designated Buildings 3-1
3-2	ECO #2: Annual Energy Use Data 3-2
3-3	ECO #2: Economic Summary 3-2
3-4	ECO #4: Annual Energy Use Data 3-4
3-5	ECO #4: Economic Summary 3-4
3-6	ECO #9: Annual Energy Use Data 3-5
3-7	ECO #9: Annual Energy Use Data 3-6
3-8	ECO #9: Economic Summary 3-6
3-9	ECO #10: Annual Energy Use Data 3-8
3-10	ECO #10: Economic Summary 3-9
3-11	ECOs #12 & #13: Annual Energy Use Data 3-11
3-12	ECOs #12 & #13: Economic Summary 3-11
3-13	ECO #17: Annual Energy Use Data 3-13
3-14	ECO #17: Economic Summary 3-14
3-15	ECOs #19 & #20: Annual Energy Use Data 3-16
3-16	ECOs #19 & #20: Economic Summary 3-16
3-17	General ECO Evaluation Summary 3-18
4-1	Annual Energy Use Data - Lighting 4-5
4-2	Economic Summary - Lighting 4-5
4-3	Annual Energy Use Data - Chiller Waste Heat Recovery 4-6
4-4	Economic Summary - Chiller Waste Heat Recovery 4-6
4-5	Annual Energy Use Data - Dry Bulb Economizers 4-7
4-6	Economic Summary - Dry Bulb Economizers 4-8
4-7	Annual Energy Use Data - Thermal Chilled Water Storage 4-9
4-8	Economic Summary - Thermal Chilled Water Storage 4-9
4-9	Annual Energy Use Data - Variable Air Volume 4-10
4-10	Economic Summary - Variable Air Volume 4-10

LIST OF TABLES (Concluded)

<u>Table</u>	<u>Page</u>
4-11 Annual Energy Use Data - Consolidated Chillers	4-11
4-12 Economic Summary - Consolidated Chillers	4-12
4-13 Annual Energy Use Data - Summary	4-12
4-14 Economic Summary	4-13
4-15 Annual Energy Use Data	4-14
4-16 Economic Summary	4-14
4-17 Annual Energy Consumption Data of ECOs with Synergism	4-15
4-18 Economic Summary of ECO Performance with Synergism	4-15
5-1 Annual Energy Use Data: Building 21140	5-2
5-2 Economic Summary: Building 21140	5-3
5-3 Annual Energy Use Data: Building 21695	5-4
5-4 Economic Summary: Building 21695	5-5
5-5 Annual Energy Use Data: Building 24072	5-7
5-6 Economic Summary: Building 24072	5-7
5-7 Annual Energy Use Data, Building 24072	5-8
5-8 Economic Summary, Building 24072	5-8
6-1 Equipment and Performance Data (Baseline)	6-17
6-2 Launch Complex 38 Chiller Plant Study Summary	6-20
7-1 Annual Energy Use Data, Building 23640	7-2
7-2 Economic Summary, Building P23640	7-3
7-3 Annual Energy Use Data, Building P23642	7-4
7-4 Economic Summary, Building P23642	7-4
8-1 Tech Area Buildings Baseline Data	8-11
8-2 Tech Area Annual Energy Use Data	8-21
8-3 Economic Summary	8-21
9-1 ECOs to be Evaluated for Designated Buildings	9-1
9-2 Recommended General ECOs	9-3
9-3 Nonrecommended General ECOs	9-4
9-4 Recommended ECOs, P300	9-6
9-5 Nonrecommended ECOs, P300	9-7
9-6 Baseline Energy Data	9-8
9-7 Recommended ECOs, P21140, P21695, P24072	9-8
9-8 Nonrecommended ECOs, P21140, P21695, P24072	9-9
9-9 Summary of ECOs, LC38	9-10
9-10 Recommended ECOs, P23640, P23642	9-11
9-11 Nonrecommended ECOs, Tech Area	9-14
10-1 Data Summary for Energy Projects	10-2

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
6-1 Launch Complex 38 Site Map	6-2
6-2 Alternatives 1A and 1B Site Plan and Layout	6-18
6-3 Alternatives 2A and 2B Site Plan and Layout	6-19
8-1 Tech Area Site Map	8-2
8-2 Main Post January 1991 Average Demand Profiles	8-5
8-3 Main Post July 1991 Average Demand Profiles	8-6
8-4 Main Post October 1991 Average Demand Profiles	8-7
8-5 Tech Area Chilled Water Load Profile	8-12
8-6 Plant Siting and Chilled Water Piping Distribution Network	8-13
8-7 Steam Distribution Piping	8-14
8-8 Alt. #1 Schematic Diagram	8-15
8-9 Alt. #2 Schematic Diagram	8-17
8-10 Alt. #3 Schematic Diagram	8-19
8-11 Alt. #4 Schematic Diagram	8-20

LIST OF PHOTOGRAPHS

<u>Photograph</u>	<u>Page</u>
6-1 Cooling Tower at P24066	6-5
6-2 Wooden Diffusers on Top of Cooling Tower	6-6
6-3 Cooling Tower Fan Drive Motor	6-7
6-4 Cooling Tower Roof Deck	6-8
6-5 Supporting Wooden Beams of the Cooling Tower	6-9
6-6 Metal Bracket in the Cooling Tower Foundation	6-10
6-7 Entrance to a Pipe Tunnel that Connects to Building P24072	6-11
6-8 Building P24072 with the Piping Tunnel on the Left	6-12
6-9 A Tower Water Coil in Building P24072	6-13
6-10 Close-up View of a Tower Water Supply Pipe	6-14
6-11 Tower Water System Piping in P24072	6-15
6-12 Tower Water Cooling Piping in P24072	6-16

LIST OF ABBREVIATIONS

ac	-	alternating current
ACCU	-	air cooled condensing unit
ACH	-	air changes per hour
ACU	-	air conditioning unit
AFUE	-	Annual Fuel Use Efficiency
AHU	-	air handling unit
amp	-	Ampere (amp, amps)
ASHRAE	-	American Society of Heating, Refrigeration, and Air Conditioning Engineers
Bldg	-	Building
Btu	-	British thermal units
Btuh	-	British thermal units per hour
cfm	-	cubic feet per minute
COMP	-	compressor
COND	-	condenser
COP	-	Coefficient of performance: ratio of the tons of refrigeration produced to the energy required to operate the equipment.
CR	-	condenser water return
CS	-	condenser water supply
cu ft	-	cubic foot, cubic feet
CWR	-	chilled water return
CWS	-	chilled water supply
DDC	-	direct digital control
DEHL	-	Director of Engineering, Housing, and Logistics
DHW	-	domestic hot water
DSM	-	demand side management
DX	-	direct expansion
EA	-	each
ECIP	-	Energy Conservation Investment Program
ECO	-	Energy Conservation Opportunity
EMC	-	E M C Engineers, Inc.
EMCS	-	Energy Management and Control System
F	-	Fahrenheit
ft	-	foot, feet

ft ²	- square feet
ft ³	- cubic feet
GEN	- generator
gph	- gallons per hour
gpm	- gallons per minute
H/C	- heating/cooling
HPS	- high pressure steam
HRSG	- heat recovery steam generator
hr	- hour(s)
H&V	- heating and ventilating
HVAC	- heating, ventilating, and air conditioning
in.	- inch(es)
I/O	- input/output
KBtu	- One thousand Btus
kcf	- thousands of cubic feet
kW	- kilowatt, one thousand watts
kWh	- kilowatt-hour, one thousand watthours
kV	- kilovolt, one thousand volts
LCC	- Life Cycle Cost
LCCA	- Life Cycle Cost Analysis
lf	- linear foot
LPS	- low pressure steam
LS	- Lump Sum
MBH	- Btu per hour (million)
MBtu	- British thermal units (million)
mWh	- megawatt-hour, one million watt-hours
MZU	- multiple zone unit
N/A	- Not Available or Not Applicable
neg	- negative
no.	- number
O&M	- operation and maintenance
PEICIP	- Productivity Enhancing Capital Investment Program
PTAC	- packaged terminal air conditioner
RAF	- return air fan
R-value	- The resistance to heat flow expressed in units of (ft ²) x (hours) x (°F)/Btu; R-value = 1/U-value.

SAF	-	supply air fan
SF	-	square feet
SIR	-	Savings-to-Investment Ratio: total life cycle benefits divided by 90% of the differential investment cost.
SPB	-	simple payback in years
SZU	-	single zone unit
UPW	-	uniform present worth factor: a factor, which when applied to annual savings, will account for the time value of money and inflation over the life of the project.
U.S.	-	United States
U-value	-	A coefficient expressing the thermal conductance of a composite structure in Btu per (sq ft) (hour) (degrees F temperature difference); $\text{Btu}/(\text{ft}^2 \times \text{hr} \times ^\circ\text{F})$.
VAV	-	variable air volume
VSD	-	variable speed drive
W	-	watt(s)
WSMR	-	White Sands Missile Range
yr	-	year(s)

EXECUTIVE SUMMARY

INTRODUCTION

Purpose

The purpose of this study is to analyze the application of selected Energy Conservation Opportunities (ECOs) to designated buildings and systems at the White Sands Missile Range (WSMR). The study has nine elements:

1. Perform a field survey of designated buildings.
2. Evaluate ten ECOs applied selectively to 45 buildings in the Main Post Area. (General ECOs).
3. Evaluate six specified ECOs at Building P300.
4. Perform complete energy surveys on Buildings P21140, P21695, and P24072.
5. Evaluate the refurbishment of the chilled water plant in P24066 to serve four buildings in Launch Complex 38.
6. Identify and evaluate other ECOs. (Contractor-identified ECOs)
7. Analyze historical electrical demand readings for the Main Post Area and recommend ways to reduce and limit peak demand. (Demand Side Management)
8. Evaluate the feasibility of constructing a consolidated chilled water plant to serve the Tech Area. Consider thermal storage and cogeneration as alternatives.
9. Present all findings and recommendations in a comprehensive report.

Recent Historical Energy Consumption for WSMR Lower Range

Both electrical energy consumption and peak electrical demand have been quite constant for FY89, FY90, and FY91.

Electricity	FY89	FY90	FY91
Electrical energy (kWh)	100,656,817	100,335,675	100,241,069
Average peak electrical demand (kW)	18,150	17,760	17,550

The 1991 electrical unit prices are \$0.0221/kWh and \$19.50/kW. FY91 electrical energy costs were \$2,241,268, whereas on peak demand charges were \$4,110,113. Currently, the peak demand charge is almost twice the electrical energy charge.

Natural gas consumption is decreasing slightly:

Natural Gas	FY89	FY90	FY91
Total kcf	275,184	268,695	247,931

The current unit gas price (1,031 Btu/cu ft) is \$2.2124/MBtu.

Launch Complex 38 is supplied propane gas at a unit price of \$6.71 per million BTU.

For the entire WSMR, the specific energy consumption (kBtu/SF) and goal are indicated below:

	Actual (kBtu/SF)	Goal (kBtu/SF)
FY85	133.95	--
FY91	123.34	127.52
FY2000	--	107.16

GENERAL ECOs

Table ES-1 below lists the general ECOs evaluated for designated buildings.

TABLE ES-1
ECOS TO BE EVALUATED FOR DESIGNATED BUILDINGS

ECO #	Short Title	Designated Buildings
2	Add roof insulation	T117, P1830
4	Lower ceiling	P1782, P1830, P1530
7	Install air curtains	P160
9	Replace windows with energy efficient windows	P100, P102, P124, P128, P129, P143, P501, P502, P503, P504
10	Install instantaneous domestic water heaters (point-of-use)	P102, P124, P153, P236, P254, P260, P300, P380, P464, P1504, P1506, P1512, P1526, P1528, P1530, S1558, P1621, P1622, P1624, P1751, S1753, S1790, P1794
12	Replace existing lighting fixtures	P1743, P1751, S1753, S1790, P1794, P1830, P1845
13	Replace old fluorescent fixtures with efficient fixtures, lamps and ballasts	P1743, P1751, S1753, S1790, P1794, P1830, P1845
17	Install infra-red or radiant gas heaters in high bay areas	S1550, S1554, P1644, S1680, P1751, S1753, P1788, P1794, P1827, P1833
19	Install thermostatically controlled radiator/convactor valves	P100, P124
20	Modify heating controls	P100, P124
29	Install a steam booster heater on a dishwasher	P1330
30	Install a boiler for summer domestic hot water load	P236

ECO #4 (lower ceiling) was not evaluated for Buildings P1530 and P1782, as during the survey it was determined that energy would not be saved.

The Consolidated Mess, Building P160, was not evaluated for ECO #7 (air curtains) because air curtains are already installed on the entries and exits.

ECO #10 (electric point-of-use water heaters) is not practically feasible for P236 (gymnasium) and P1621 (photo lab).

ECO #19 applies to Building P100. ECO #20 applies to P124. Both involve modifying heating controls, and are evaluated as a single ECO.

ECO #29 (install steam booster heater on a dishwasher) was not evaluated at Building P1330, because one is already in place.

The results of the evaluations are shown in Tables ES-2 and ES-3.

TABLE ES-2
RECOMMENDED GENERAL ECOs

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P124	19-20	Install heating control valves/modify heating controls	747.3	1,779	5,191	3.3	3.8
S1790	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	57.0	369	9,643	5.0	2.9
P1794	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	135.1	875	24,962	5.5	2.7
P1743	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	119.3	773	26,824	6.7	2.2
P1845	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	1.1	7	281	7.4	2.0
P1751	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	38.0	246	9,515	7.5	2.0
P100	19-20	Install heating control valves/modify heating controls	839.4	2,082	12,071	6.5	1.9
P1830	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	45.7	296	12,211	8.0	1.9
S1753	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	26.6	174	7,396	8.2	1.8
T117	2	Add roof insulation	45.6	109	1,450	14.9	1.3
P1794	17	Infrared heaters in high-bay areas	369.4	906	14,602	9.7	1.2
P1788	17	Infrared heaters in high-bay areas	111.8	270	5,677	10.3	1.1
P1827	17	Infrared heaters in high-bay areas	226.0	517	10,695	11.5	1.0
P1751	17	Infrared heaters in high-bay areas	223.3	532	10,584	11.7	1.0

2,985.6 8,935

**TABLE ES-3
NONRECOMMENDED GENERAL ECOs**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P1833	17	Infrared heaters in high-bay areas	117.2	278	8,268	13.8	0.8
S1644	17	Infrared heaters in high-bay areas	65.3	232	3,873	13.9	0.8
S1753	17	Infrared heaters in high-bay areas	91.3	221	6,793	14.4	0.8
P502	9	Replace windows with energy efficient windows -grey glass	30.0	187	29,046	17.6	0.8
P502	9	Replace windows with energy efficient windows -clear glass	30.3	196	26,747	21.2	0.7
S1550	17	Infrared heaters in high-bay areas	140.6	531	10,313	18.0	0.6
S1554	17	Infrared heaters in high-bay areas	140.6	531	10,313	18.0	0.6
S1680	17	Infrared heaters in high-bay areas	241.6	577	10,530	20.3	0.6
P501A	9	Replace windows with energy efficient windows -grey glass	33.0	213	42,361	24.2	0.6
P501A	9	Replace windows with energy efficient windows -clear glass	33.0	213	39,008	26.9	0.6
S1790	10	Install instantaneous DHW heaters	28.9	53	2,334	49.2	0.4
P1751	10	Install instantaneous DHW heaters	21.2	39	2,324	67.3	0.3
P1506	10	Install instantaneous DHW heaters	86.3	106	9,176	96.4	0.3
P1512	10	Install instantaneous DHW heaters	37.4	72	8,458	131.8	0.2
P1830	4	Lower ceiling	66.9	114	93,109	124.9	0.1
P124	9	Replace windows with energy efficient windows	312.4	764	102,092	149.0	0.1
P501B	9	Replace windows with energy efficient windows -clear glass	69.0	160	27,507	154.4	0.1
P129	9	Replace windows with energy efficient windows	73.4	240	37,866	175.6	0.1
P143	9	Replace windows with energy efficient windows	73.4	240	37,866	175.6	0.1
P128	9	Replace windows with energy efficient windows	135.9	402	72,187	200.1	0.1
P153	10	Install instantaneous DHW heaters	10.1	11	2,314	243.1	0.1

**TABLE ES-3
NONRECOMMENDED GENERAL ECOs (Concluded)**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
S1753	10	Install instantaneous DHW heaters	9.7	10	2,314	251.2	0.1
P100	9	Replace windows with energy efficient windows	188.2	251	57,602	256.3	0.1
P102	9	Replace windows with energy efficient windows	43.1	101	27,622	305.2	0.1
P504	9	Replace windows with energy efficient windows	46.3	118	32,969	310.4	0.1
P503	9	Replace windows with energy efficient windows	54.9	133	40,750	342.5	0.1
P380	10	Install instantaneous DHW heaters	11.3	21	7,620	400.8	0.1
P1622	10	Install instantaneous DHW heaters	44.2	32	12,378	430.6	0.1
P254	10	Install instantaneous DHW heaters	18.4	10	4,628	529.2	0.1
P1528	10	Install instantaneous DHW heaters	33.3	8	6,234	857.7	0.1
P102	10	Install instantaneous DHW heaters	33.5	10	7,820	891.6	0.1
P124	10	Install instantaneous DHW heaters	36.1	19	16,158	927.4	0.1
P260	10	Install instantaneous DHW heaters	11.9	3	3,830	1382.8	0.1
P1794	10	Install instantaneous DHW heaters	13.6	10	12,374	1410.7	0.1
P300	10	Install instantaneous DHW heaters	78.7	14	20,826	1704.1	0.1
P1624	10	Install instantaneous DHW heaters	39.3	2	10,892	7394.5	0.1
P1504	10	Install instantaneous DHW heaters	27.7	(4)	3,830	N/A	N/A
P464	10	Install instantaneous DHW heaters	9.0	(8)	4,588	N/A	N/A
S1558	10	Install instantaneous DHW heaters	15.2	(13)	7,666	N/A	N/A
P1530	10	Install instantaneous DHW heaters	45.6	(47)	12,408	N/A	N/A
P1526	10	Install instantaneous DHW heaters	7.0	(51)	6,104	N/A	N/A
P1621	10	Install instantaneous DHW heaters	212.0	(1,210)	2,314	N/A	N/A

BUILDING P300: RANGE CONTROL

The following ECOs were designated in the Scope of Work for P300:

1. Use more efficient lighting fixtures.
2. Reduce lighting levels.
3. Use recovered waste heat.
4. Use dry bulb economizers.
5. Reduce outside air quantities.
6. Use thermal storage for demand reduction.
7. Convert constant volume air handlers to variable air volume.
8. Consolidate multiple air-cooled chillers onto two high-efficiency, water-cooled centrifugal chillers.

ECO #2 was not evaluated because lighting energy conservation is widely practiced in the building. ECO #5 was not evaluated because makeup air is currently a fixed rate that is in compliance with ventilation standards.

Tables ES-4 and ES-5 present the results of the evaluated ECOs.

TABLE ES-4
RECOMMENDED ECOs, P300

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Total Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P300	6	Thermal storage	(224.3)	40,285	165,000	4.6	3.3
P300	8	Convert existing chiller plant to consolidated chiller plant	635.0	4,112	56,100	5.2	2.9
P300	1	Replace lighting fixtures with efficient fixtures, lamps, & ballasts	190.0	1,305	38,783	6.0	2.5
P300	7	Convert existing AHUs to variable-air-volume	4877.6	28,301	268,913	6.0	1.8

**TABLE ES-5
NONRECOMMENDED ECOS**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Total Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P300	3	Waste heat recovery from chiller plant	2607.8	7375	91,996	7.4	2.2
P300	4	Dry bulb economizers on AHUs	(798)	3,970	149,536	14.9	0.7

BUILDING ENERGY SURVEYS

Complete energy surveys were performed at Buildings P21140, Temperature Test Facility, P21695, Special Weapons Assembly Building (SWAB), and P24072, Helicopter Drone Maintenance Facility.

The TRACE 600 program was used to model the existing building baseline and ECO configurations. Each of these buildings was constructed as a special use facility, and applicable ECOs are very limited.

Table ES-6 presents baseline energy consumption data, and Tables ES-7 and ES-8 present ECO evaluation results.

**TABLE ES-6
BASELINE ENERGY DATA**

Building	Annual Energy Consumption			Specific (Btu/SF)
	Elec. (kWh)	Elec. Demand (kW)	Gas (MBtu)	
P21140 (no temperature test energy use included)	458,686	94	0	66,250
P21695	252,112	81.3	869.6	99,147
P24072	452,691	61.9	(Propane) 659.0	61,989

TABLE ES-7
RECOMMENDED ECOs, P21140, P21695, P24072

Bldg. No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P21695	Setback/ thermostats	517.4	1,675	136	0.1	128.0
P24072	Modify HVAC Controls	359.2	2,366	2,016	0.7	16.6
P24072	Replace lighting fixtures with efficient fixtures, lamps & ballasts; disconnect lighting in non-use areas	376.8	2,361	11,338	1.9	6.9
P21140	Replace lighting fixtures with efficient fixtures, lamps & ballasts	1.1	7.3	281	7.4	2.0
P21695	Replace lighting fixtures with efficient fixtures, lamps & ballasts	6.4	90	4,259	8.2	1.8
21140	Reduce stratification	12.8	234	4,077	13.6	1.1

TABLE ES-8
NONRECOMMENDED ECOs, P21140, P21695, 24072

Bldg. No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P24072	Dry-bulb economizer on AHU	10.2	66.2	2,047	21.7	0.5
P21695	Replace windows with energy efficient windows	6.0	29.0	5,107	83.0	0.2
P21695	Dry-bulb economizer on AHU	0.6	5.0	997	242	0.1

LAUNCH COMPLEX 38

The chilled water plant located in P24066 was surveyed to determine the feasibility of refurbishing the plant and using it to supply P24072, P23638, P23640, and P23642 in Launch Complex 38. It was determined that the condenser water side of the plant is too deteriorated to refurbish and the two 550-ton chillers are much too large in capacity to efficiently supply the load on the four buildings. While, P24066 is adjacent to P24072, it is a mile away from the other three buildings. Piping costs are prohibitive.

Four chilled water (CW) plant alternatives were identified and evaluated:

Alt. #1A: Install a CW plant near P23638 with air-cooled chillers to supply the four buildings.

Alt. #1B: Install a CW plant near P23638 with water-cooled chillers to serve the four buildings.

Alt. #2A: Install CW plant near P23642 with air-cooled chillers to serve P23638, P23640, and P23642. Use the existing air-cooled chillers at P24072 to serve that building.

Alt. #2B: The same as for Alt. #2A except use water-cooled chillers in the new plant.

The results are shown in Table ES-9.

**TABLE ES-9
SUMMARY OF ECOs, LC38**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
LC38 Chiller Plant Study	Alt #2B	130-ton water-cooled chiller plant	4,161	26,966	367,262	7.8	2.2
LC38 Chiller Plant Study	Alt #2A	140-ton air-cooled chiller plant	3,974	25,751	325,091	9.4	1.9
	Alt #1A	200-ton air-cooled chiller plant	4,505	29,190	371,979	11.5	1.6
	Alt #1B	150-ton water-cooled chiller plant	4,691	30,398	703,072	15.8	1.1

At the time of the interim report presentation and review conference (May 28, 1992), it was learned that new air-cooled chillers have been installed at P23640. Also, a work order for new air-cooled chillers for P23638 has been requested. As a result, it is not feasible to proceed with any of the 4 alternatives considered, and none is recommended for implementation.

CONTRACTOR-IDENTIFIED ECOs

Buildings P23640 and P23642 were constructed as special purpose mission support buildings for the Nike Zeus program, which was discontinued about 30 years ago. The buildings are currently used to support new missions, totally incompatible with the original building designs. Several ECOs at each building were identified that potentially would save energy and correct severe building discrepancies for the current occupants.

In the case of both buildings, a modified configuration consisting of several ECOs was evaluated and compared to the baseline configuration.

Modified Configurations

P23640:

- Upgrade AHU-2 by installing a chilled water coil, repairing the makeup air damper actuator, and installing a dry bulb economizer control.
- Replace the fan motor on AHU-1 with a high efficiency motor and reduce supply airflow rate to 1.5 cfm/SF.

- Optimize the supply air temperature setpoint on AHU-1 and AHU-2.
- Install a 6°F chilled water setpoint reset on the two 50 ton chillers and control the returned chilled water to 55°F.
- Replace standard fluorescent lamps and ballasts with low wattage lamps and ballasts.

P23642:

- Replace standard fluorescent lamps and ballasts with low wattage lamps and ballasts.
- Reduce supply cfm on all 3 AHUs.
- Install dry bulb economizers on all 3 AHUs.
- Replace fan motors on all AHUs with smaller, high efficiency motors.

Results: The baseline and modified configuration were evaluated for each building using the TRACE 600 program. The results for the modified configurations are shown in Table ES-10 below.

**TABLE ES-10
RECOMMENDED ECOs, P23640, P23642**

Bldg. No.	Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P23640	Modified configuration	1,065	6,938	15,025	1.1	10.2
P23642	Modified configuration	171	1,104	24,053	4.3	2.5

DEMAND SIDE MANAGEMENT (DSM)

Copies of El Paso Electric Utility demand meter records for January, July, and October for 1989, 1990 and 1991 were analyzed, and measures to reduce and control on peak electrical demand were recommended.

Typical Demand Profiles: The following data characterize typical workday and nonworkday electrical demand profiles at the Main Post Area. On peak refers to the period from 0730 hours to 1630 hours, and off peak to the rest of the day. The demand kW values shown are nominal maximums.

Workdays	Offpeak kW	On Peak kW	Rise kW
January 1991	5,000	7,800	2,800
July 1991	6,000	11,700	5,700
October 1991	5,000	8,500	3,700
Nonworkdays			
January 1991	5,500	5,300	-200
July 1991	6,000	6,700	700
October 1991	4,800	5,500	700

The average El Paso Electric Company peak demand for WSMR is 10,150 kW, and is referred to as the conjunctive peak. It is the sum of peak kW readings recorded at each of the six substations corresponding to the date and time of the highest monthly demand registered. Usually the peak demand occurs at the time the Main Post substation peaks. Note that the Main Post Area peak demand occurs in July, and is nominally 11,700 kW, or about two-thirds of the conjunctive peak. The demand profiles at the other 5 substations are relatively flat, so the opportunities for DSM exist primarily at the Main Post Area.

DSM Opportunities: The significant opportunities to reduce peak electrical demand are shown in the matrix below. The electric service contract contains no demand ratchet clause, which increases opportunities for reducing demand charges.

<u>Opportunity</u>	<u>Priority</u>	<u>Annual Dollars Saved (\$/kW)</u>
Install efficient lighting systems	High	427.60
Thermal storage for chillers	Medium	234.00
Reduce excessive supply airflows	Medium	234.00
Install high efficiency motors	Low	427.60
Convert AHUs to VAV	High	234 to 427.60

At the time of this report submittal, the only DSM rebate available from El Paso Electric Company is \$190.00 per kW of shifted load, which applies only to thermal storage.

CONSOLIDATED CHILLED WATER PLANT TO SERVE THE TECH AREA

General: Nine buildings in the Tech Area have chilled water systems, and there is a continuous chilled water load in a few buildings. It is necessary to operate some chillers all year long. Most of the existing refrigeration units are air-cooled cold generators and are quite inefficient in hot ambient temperature conditions. Four consolidated chilled water plant alternatives were evaluated, each using water-cooled equipment.

Alt. #1: Consolidated chilled water plant without chilled water thermal storage.

Alt. #2: Same as Alt. #1 but with chilled water thermal storage.

Alt. #3: Cogeneration plant with gas turbine-generator set, steam driven rotary chillers, and heat recovery steam generator.

Alt. #4: Same as Alt. #3 except the chillers are steam powered double effect absorption chillers.

Each alternative includes a chilled water loop to serve the nine buildings, sized for the summer peak load. Alt. #3 and Alt. #4 include a steam and condensate loop that serves all heated buildings in the Tech Area.

Table ES-11 presents the results. None of the alternatives qualifies for implementation under the ECIP guidelines.

**TABLE ES-11
NONRECOMMENDED ECOs, TECH AREA**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$1,000)	SPB (yrs)	SIR
Technical Area Chiller Plant Study	Alt. #1	Consolidated chiller plant w/o thermal storage	7,654	49,559	1,681	N/A	0.53
	Alt. #2	Consolidated chiller plant w/chilled water storage	7,410	47,981	2,378	N/A	0.37
	Alt. #3	Cogeneration plant w/steam turbine-driven chillers	(54,001)	(93,273)	4,814	142	0.01
	Alt. #4	Cogeneration plant w/absorption chillers	(45,646)	(50,767)	4,592	114	0.04

The recommended solution for the Tech Area chilled water systems is to continue to use the existing air-cooled chillers, but to install precoolers on each air-cooled chiller. This will reduce the kW demand somewhat, and will conserve electrical energy. Replacement with water-cooled equipment would provide better demand reduction, but would significantly increase maintenance and saving requirements, is is therefore not recommended.

IDENTIFIED ENERGY RETROFIT PROJECTS

Four buildings were identified for energy retrofit projects:

- | | |
|-------|---|
| No. 1 | Modifications to P300 to include: <ul style="list-style-type: none">• convert air handlers to VAV• replace one air-cooled chiller with a water-cooled unit• replace all standard 40 watt fluorescent lamps and standard ballasts with reduced wattage lamps and ballasts• install a chilled water thermal storage system |
| No. 2 | Modifications to P24072 to include: <ul style="list-style-type: none">• improved fluorescent lighting system• setback thermostat• install cooling coil control valve |
| No. 3 | Modifications to P23640 to include: <ul style="list-style-type: none">• improved fluorescent lighting• modifications to both air handlers |
| No. 4 | Modifications to P23642 to include: <ul style="list-style-type: none">• improved fluorescent lighting• modifications to three air handlers |

Project energy savings and economic parameters are presented in Table ES-12.

**TABLE ES-12
DATA SUMMARY FOR ENERGY PROJECTS**

Bldg. No.	Project Description	Construction Cost (\$)	Funding Authority	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	SPB (yrs)	SIR
P300	Modified configuration	446,296	ECIP	5,488	32,367	4.7	2.3
P24072	Improve fluorescent lighting, setback thermostat, install cooling coil control valve	13,355	OMA & unit funds	8,662.4	5,741	1.5	7.3
P23640	Improve fluorescent lighting, modify both AHUs	15,025	OMA & unit funds	1,064.7	6,938	1.1	10.2
P23642	Improve fluorescent lighting, modify 3 AHUs to reduce air flow	24,053	OMA & unit funds	171.5	1,103	4.3	2.5

Sub-total	-	15,382.6	40,408
O & M, 1985-4		2,985.6	8,935
Total		18,372.2	49,343

SECTION 1.0

INTRODUCTION

1.1 AUTHORITY

This study was conducted and this report prepared under Contract No. DACA63-91-C-0152. The contract was issued and administered by the U.S. Army Engineer District, Fort Worth.

1.2 PURPOSE

The purpose of this report is to present the results of a study analyzing energy conservation opportunities (ECOs) at the White Sands Missile Range (WSMR), New Mexico.

1.3 SCOPE OF WORK

The study includes seven tasks:

1. Analyze 45 designated buildings in the main post area for general ECOs.
2. Evaluate demand side management opportunities for the main post area:
 - Analyze the application of cogeneration and of a central chilled water plant with thermal storage for the Tech Area.
 - Examine electric demand billing for the main post area for the last 3 years.
 - Make recommendations for the reduction and control of electric demand in the main post area.
3. Perform energy analyses for designated existing buildings:

Building P-300: Evaluate the application of

- a centralized chilled water plant,
- variable air volume to the air delivery systems,
- thermal storage for the chilled water system,
- reducing outside air quantities if they exceed the ASHRAE Standard,
- dry bulb economizers on the air handlers,
- reducing existing lighting levels,
- using more efficient lighting fixtures,
- the use of waste heat recovery.

Launch Complex 38:

- Evaluate the refurbishment of the central chiller plant in Building P-24066 to serve P-24072, P-23638, P-23640 and P-23642.
- 4. Conduct energy surveys of buildings P-21695, P-24072, and P-21140.
- 5. Identify other ECOs for evaluation during the field survey of the designated buildings.
- 6. Prepare the LCCA summary sheets, project descriptions and backup calculations to support the documentation of recommended projects.
- 7. Present all work, findings, results and recommendations in a comprehensive report.

The Scope of Work is included in Appendix A. Modifications to the Scope of Work are documented in Confirmation Notices No. 007, 008 and 009, also in Appendix A.

1.4 ORGANIZATION OF THE REPORT

This report consists of two volumes in three binders plus a separately bound Executive Summary:

- Volume I Book 1 presents the analysis and results of the various ECO evaluations and program documentation. It contains the main body of the report and Appendices A, B, and C.
- Volume I Book 2 contains Appendix D, backup data and calculations.
- Volume II contains the completed building survey forms.
- The Executive Summary is also provided in a separate binder.

This volume, Volume I Book 1, is organized as follows:

- Section 2.0 presents the historical energy consumption of the main post area of the White Sands Missile Range for the last three years, and presents current energy unit prices.
- Section 3.0 presents the evaluations of the general ECOs applied to 45 designated buildings.
- Section 4.0 presents the results of analysis of Building P-300.
- Section 5.0 presents the building energy surveys of P21140, P21695 and P24072.
- Section 6.0 presents the analysis of the chilled water plant in P24066.

- Section 7.0 presents the results of certain contractor-identified ECOs.
- Section 8.0 presents data and analysis of the main post area electrical demand, and a consolidated chiller plant study for the Tech area, a special group of buildings within the main post area.
- Section 9.0 presents a summary of the economic analyses for all ECOs with results prioritized by Savings to Investment Ratio.
- Section 10 presents the grouping of ECOs into projects for funding, and summarizes the various projects.
- Appendix A presents the Scope of Work and Confirmation Notices.
- Appendix B presents the Trane TRACE 600 program description.
- Appendix C presents the program documentation support data for the Energy Conservation Investment Program (ECIP) project in Building P300 and the Scopes of Work for construction projects in Buildings P23640, P23642, and P24072.

1.5 METHODOLOGY

Project tasks may be grouped into four main elements:

- Survey
- Analysis
- Project documentation
- Reporting

1.5.1 Survey

A site survey was conducted to visually inspect the buildings for conditions that pertain to the evaluation of the specified ECOs, to interview building tenants, and to observe normal operation of the building. As-built drawings were obtained from Director of Engineering, Housing, and Logistics (DEHL) personnel and, whenever possible, data on the as-builts were confirmed by field observation. Data on recent roofing contracts, boiler replacements, chiller replacements, and other recent modifications to buildings were received from DEHL shop supervisors. Field survey forms are included in Volume II.

1.5.2 Analysis

Most ECOs were evaluated using the Trane TRACE 600 building simulation program. Some were evaluated with hand calculations. A few analyses were made using Lotus spreadsheets. The El Paso Texas weather file was obtained for use with the TRACE 600 building energy simulation program.

For hand calculations using heating and cooling degree days, and temperature bin charts, Army Technical Manual 5-785 (1989) data for Fort Bliss, Texas was used.

The first step in each ECO analysis was the calculation of the energy consumption of the existing building configuration. In some cases this entailed establishing the annual baseline energy use of the entire building. Then the energy consumption was calculated for the modified building or system with the ECO in place. The difference between the two levels of energy consumption is the energy savings for the specified ECO. Data from the as-built drawings, the field survey, and equipment manufacturer's performance catalogs were used in the calculation or simulation of equipment performance. Equipment cost estimates were based on the 1991 Means Mechanical Cost Data, the 1991 Means Construction Cost Data, and on price quotes from equipment dealers. Labor rates are the U.S. Department of Labor approved rates for New Mexico.

Finally, the Life Cycle Cost Analysis (LCCA) of each ECO was completed in accordance with the latest ECIP guidelines.

Backup data for all evaluations are found in Volume I Book 2 (Appendix D), and is tabbed for the reader's convenience.

1.5.3 Project Documentation

Project LCCA summary sheets, cost estimates, project descriptions and backup data and calculations are included in Appendix C located in this Volume I Book 1 for recommended projects.

1.5.4 Reporting

The reporting includes writing and assembling the report and presenting the results of the report at a meeting with various reviewers.

1.6 RESULTS OF PREVIOUS STUDIES

An Energy Engineering Analysis Program (EEAP) study was completed at the White Sands Missile Range in 1981 by Southwestern Energy Group of El Paso, Texas. The study recommended 9 ECIP projects, 5 other projects (no funding program identified), and 14 Low Cost/No Cost projects. The 9 ECIP and 5 other type projects have not yet been implemented. The Low Cost/No Cost projects involve routine, noncritical maintenance practices, and are accomplished within the limitations of available maintenance personnel and the O & M budget.

1.7 ACCOMPLISHMENTS UNDER THIS STUDY

The Notice to Proceed was received on October 21, 1991. The field survey was completed on November 15, and the interim report was submitted in 3 volumes on April 16, 1992. Review

comments were received on May 22, 1992 and the interim report presentation and review conferences were held at the White Sands Missile Range on May 28 and May 29. Instructions for packaging ECOs into projects were received at the May 29 meeting.

1.8 PREFINAL REPORT

Upon receipt of the reviewers' comments on the interim report, a formal presentation and review was given at the DEHL offices at the WSMR. Included in the review were groups of ECOs packaged into projects for implementation under the various funding authorities (ECIP, PECIP, etc.). Upon conclusion of the review, work resumed to prepare the prefinal report. The various recommended projects were reevaluated to account for any reduction of total energy savings resulting from the simultaneous implementation of more than one ECO, if any, and the project economic evaluations were made. The required project documentation was prepared: LCCA summary sheets, project descriptions, backup calculations, cost estimates, and other backup materials were assembled. The prefinal report was submitted on August 28, 1992.

1.9 FINAL REPORT

Reviewers' comments were received on September 28, 1992. Corrections were made and the final report was delivered on November 16, 1992.

SECTION 2.0

HISTORICAL ENERGY CONSUMPTION FOR WSMR LOWER RANGE

2.1 GENERAL

The data presented in this section were received from the Energy Branch, Engineering Plans and Programs Division of Engineering, Housing and Logistics at the White Sands Missile Range (WSMR). Energy consumption and cost data for the WSMR Lower Range are presented for FY 89, FY 90 and FY 91.

2.2 ENERGY CONSUMPTION BY TYPE

**TABLE 2-1
ELECTRICAL ENERGY CONSUMPTION AND COST DATA**

	FY 89		FY 90		FY 91	
	kW	kWh	kW	kWh	kW	kWh
OCT	16,515	7,448,638	17,621	8,253,240	16,014	8,310,935
NOV	15,753	7,384,855	17,737	8,053,621	15,658	7,533,266
DEC	17,456	7,875,622	16,853	7,717,551	16,093	7,366,243
JAN	17,473	8,782,873	17,088	9,034,904	16,694	9,053,601
FEB	17,267	7,742,615	16,745	7,527,030	16,412	7,437,690
MAR	16,182	8,361,184	15,616	7,710,319	15,544	7,301,483
APR	17,134	7,399,807	15,162	7,576,145	16,326	8,489,059
MAY	19,150	9,242,121	18,487	8,333,428	17,918	8,764,623
JUN	20,365	9,269,999	19,774	9,167,640	20,137	8,532,086
JUL	21,527	9,597,103	19,992	9,831,453	20,440	10,264,853
AUG	19,706	9,365,065	18,609	9,217,635	20,218	9,463,732
SEP	19,207	8,186,935	19,524	7,912,709	19,321	8,723,498
Total						
	217,735	100,656,817	213,208	100,335,675	210,775	101,241,069
Avg kW						
Demand	18,145		17,767		17,565	
Annual Cost					\$4,110,113	\$2,241,268
Unit Demand Price:			(\$/kW)		19.50	
Unit Energy Price:			(\$/kWh)			0.0221
			(\$/MBtu)			6.4752
Average Electrical Energy Price						
Including Demand Charges:			(\$/kWh)			0.0627
			(\$/MBtu)			18.3813

The electrical energy consumption shown in Table 2-1 is historical data based on conjunctive billing from El Paso Electric Company. The WSMR is served by six metered substations, and the Main Post substation metered peak demand usually determines the time of peak demand for the lower range. It is the sum of the peak demand readings recorded at each of the six substations corresponding to the date and time of the highest monthly demand registered; usually the peak demand occurs at the time the Main Post substation peaks.

TABLE 2-2
NATURAL GAS CONSUMPTION AND COST DATA

	FY 89 (kcf)	FY 90 (kcf)	FY 91 (kcf)
OCT	12,046.0	14,464.8	12,073.0
NOV	33,250.2	29,944.8	28,843.1
DEC	50,805.6	48,955.4	45,737.7
JAN	53,742.8	49,599.0	47,602.7
FEB	38,326.7	41,719.9	33,547.2
MAR	27,185.3	31,423.3	34,196.2
APR	14,397.8	16,070.8	14,053.2
MAY	10,826.1	10,727.1	7,932.5
JUN	8,782.6	6,201.4	6,226.9
JUL	8,587.9	6,269.7	6,094.6
AUG	8,267.1	6,934.8	5,503.6
SEP	8,965.7	6,384.4	6,119.9
TOTAL	275,183.8	268,695.4	247,930.6
Annual Cost			\$874,906
Unit Price (\$/kcf)			3.5288
(\$/MBtu)			3.4227
Note: Heat content is 1.031 MBtu/kcf			

In February, 1992, the WSMR began receiving natural gas under a new supply contract at a reduced cost. Table 2-3 presents consumption data for February, March and April of 1992.

TABLE 2-3
NATURAL GAS CONSUMPTION AND COST DATA
(EFFECTIVE FEBRUARY, 1992)

FY 92	MBtu	Cost
FEB	31,432	\$60,052.80
MAR	30,119	\$66,091.43
APR	16,630	\$20,339.36

Average Cost \$/MBtu: 2.2124

LC38 is supplied with propane gas at a current unit price of \$6.71/MBtu.

2.3 1985 ENERGY CONSUMPTION AND THE GOAL FOR FY2000

Specific energy consumption (kBtu/SF) for the entire White Sands Missile Range is listed for FY85 and FY91. Energy consumption goals are shown for FY91 and FY2000.

	Actual (kBtu/SF)	Goal (kBtu/SF)
FY1985	133.95	-
FY1991	123.34	127.52
FY2000	-	107.16

Energy consumption at the WSMR is strongly dependent on mission activity. In 1991 the level of mission activity was somewhat below normal.

SECTION 3.0

EVALUATION OF GENERAL ENERGY CONSERVATION OPPORTUNITIES

3.1 GENERAL

The Scope of Work lists 30 general ECOs to be evaluated for designated buildings (see Annex A, Scope of Work in Appendix A). This information is extracted and presented in Table 3-1 below for convenience.

**TABLE 3-1
ECOS TO BE EVALUATED FOR DESIGNATED BUILDINGS**

ECO #	Short Title	Designated Buildings
2	Add roof insulation	T117, P1830
4	Lower ceiling	P1782, P1830, P1530
7	Install air curtains	P160
9	Replace windows with energy efficient windows	P100, P102, P124, P128, P129, P143, P501, P502, P503, P504
10	Install instantaneous domestic water heaters (point-of-use)	P102, P124, P153, P236, P254, P260, P300, P380, P464, P1504, P1506, P1512, P1526, P1528, P1530, S1558, P1621, P1622, P1624, P1751, S1753, S1790, P1794
12	Replace existing lighting fixtures	P1743, P1751, S1753, S1790, P1794, P1830, P1845
13	Replace old fluorescent fixtures with efficient fixtures, lamps and ballasts	P1743, P1751, S1753, S1790, P1794, P1830, P1845
17	Install infra-red or radiant gas heaters in high bay areas	S1550, S1554, P1644, S1680, P1751, S1753, P1788, P1794, P1827, P1833
19	Install thermostatically controlled radiator/convactor valves	P100, P124
20	Modify heating controls	P100, P124
29	Install a steam booster heater on a dishwasher	P1330
30	Install a boiler for summer domestic hot water load	P236

Each ECO was evaluated for application to the designated buildings, and the results are presented in the following sections. First the application of the ECO concept to the various buildings is discussed. The method of analysis is then explained, and the annual energy savings, cost savings and Life Cycle Cost Analysis results are presented. Calculations or computer printouts, cost estimates and manufacturers' catalog data (if applicable) and an LCCA summary report are packaged together as ECO backup data in Appendix D which is tabbed for convenience. Individual building survey data are found in VOLUME II: BUILDING SURVEY DATA.

3.2 ECO #2: ADD ROOF INSULATION

Background: Building T117 is heated by two residential type hot air furnaces, and is evaporatively cooled. It has a pitched roof with no insulation. The building has a low ceiling throughout, which is also uninsulated. The best solution to achieve reduced heat loss through the ceiling and roof is to lay R-19 insulation batts on the ceiling. Building T117 was analyzed for increased ceiling insulation.

Building P1830 has recently been reroofed (R-value 19), and is not in need of repair or replacement. P1830 was not analyzed.

Method of Analysis: The TRACE 600 building simulation computer program was used to calculate the annual natural gas energy savings for building T117. TRACE baseline and ECO reports are included in the backup data in Appendix D, Tab 1. The baseline TRACE 600 run uses a roof U-factor of 0.280 (Btu/SF-hr-°F) and the ECO run uses U=0.044 (Btu/SF-hr-°F).

Results:

**TABLE 3-2
ECO #2: ANNUAL ENERGY USE DATA**

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
T117	10,175	4	113.6	10,034	4	68.5	141	0	45.1

**TABLE 3-3
ECO #2: ECONOMIC SUMMARY**

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
T117	9	0	100	1,450	0	15	1.3

Unit electrical energy price: \$0.0627/kWh

Unit electrical demand price: \$0/kW

Unit gas energy price: \$2.2124/MBtu

Conclusions: The addition of batt insulation above the ceiling is cost effective for T117.

3.3 ECO #4: LOWER CEILING

Background: Building P1530 has low ceilings throughout with the exception of the center hallways on the first and second floors. Neither of these areas have exposure to an exterior wall or the roof. Both hallways act as return air plenums for the building HVAC system, so are well ventilated. Lowering the ceilings in the two hallways will not save any energy, so the ECO was not evaluated for Building P1530.

Building P1782 is an administrative building with 9 ft 4 in. ceilings. It is heated by gas-fired unit heaters and is evaporatively cooled. Lowering the ceilings to 8 ft requires that the supply air ductwork be extended and that the fluorescent light fixtures be replaced. The existing fixtures are not suitable for installation in a ceiling. Lowering the ceiling to 8 ft will not result in any appreciable energy savings. Building P1782 is not a feasible candidate for lowered ceilings and no evaluation was performed.

Building P1830 has a mixture of high (16 feet) ceilings and low ceilings. Two high ceiling areas are currently heated by gas-fired infrared heaters. The remainder of the building is heated by gas unit heaters that hang from the high ceilings. Roof-mounted, evaporative coolers serve the entire building. Supply air ductwork to spaces runs under the roof, above hanging fluorescent light fixtures. Exhaust fans are installed in window openings high on the outside walls.

Lowering the ceilings will require new fluorescent light fixtures as well as new roof-mounted combination gas-furnace—evaporative cooler units with an extensive supply air duct system to serve the entire building. The exhaust fans are part of the evaporative cooling system, and must remain. Installing return air grilles in the ceilings of each room will make the above ceiling space an exhaust air plenum.

P1830 has a new R-19 roof, so no ceiling insulation was added in the ECO concept. A reduction in gas energy consumption will result, as space temperatures above the ceiling will be reduced, and roof, wall and window heat losses will decrease.

Method of Analysis: The TRACE 600 program was used to simulate the baseline and retrofit conditions of Building P1830. The TRACE 600 output reports, and all backup data are located in Appendix D, Tab 2 in Volume I Book 2.

Results:

TABLE 3-4
ECO #4: ANNUAL ENERGY USE DATA

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
1830	65,205	28	422.1	65,817	29	353.2	(612)	(1)	69

TABLE 3-5
ECO #4: ECONOMIC SUMMARY

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
1830	(38)	-	152	93,109	0	125.0	0.1

Unit electrical energy price: \$0.0627/kWh

Unit electrical demand price: \$0 /kW

Unit gas energy price: \$2.2124 MBtu

Conclusions: Building P1830 has high internal gains from lights and occupants, which offset building heat loss down to 42°F. As a result, the building has only 700 annual heating degree days. This fact combined with the lack of mechanical air-conditioning results in small gas energy savings for this ECO. In addition, the lowering of ceilings requires a new lighting system and a new heating and cooling system throughout the entire building, which further contributes to the economic infeasibility of this ECO.

3.4 ECO #7: INSTALL AIR CURTAINS

Background: Building P160 is the Consolidated Mess. The building has two entrances: one on a loading dock on the east side of the building, and the main entrance to the dining room on the south side of the building. The kitchen entrance on the loading dock is equipped with an operational air curtain, but it is mounted on the inside of the wall above the door opening instead of on the outside of the wall. The main entrance has two operational air curtains that are incorrectly mounted on the inside of the vestibule exterior wall, above the doors.

The building supervisor reports that the existing air curtains will adequately serve the consolidated mess once they are remounted on the outside walls. A work order to move the units is pending.

Method of Analysis: No analysis was performed, because no energy savings will be produced by replacing the existing air curtains.

3.5 ECO #9: REPLACE WINDOWS WITH ENERGY EFFICIENT WINDOWS

Background: The 10 buildings designated for evaluation in Section 3.1 have single pane clear glass, operational windows with metal frames. Most of the windows are of the casement type. Buildings P501A and P502 are air-conditioned by reversible heat pumps with electric resistance heaters for winter heating. Buildings P100, P124, and P501B are partially air-conditioned, with evaporative cooling in the remaining building areas. The other buildings are evaporatively cooled.

Three types of double-glazed, metal-framed, thermally clad windows for Buildings P501A and P502 were analyzed: clear glass, grey E glass, and bronze E glass. For the other buildings, only clear glass windows were analyzed. In all cases, infiltration and heat conduction losses were reduced.

Method of Analysis: The baseline and ECO energy calculations were made with the TRACE 600 program. TRACE output reports with all backup data are found in Appendix D, Tab 3 in Volume 1 Book 2.

Results:

**TABLE 3-6
ECO #9: ANNUAL ENERGY USE DATA**

Bldg. No.	Baseline			ECO (Clear Glass)			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P100	307,184	146	1683.9	310,194	146	1485.4	(3,010)	0	198.5
P102	104,326	47	285.5	104,227	47	242.7	99	0	42.8
P124	206,633	100	1347.2	205,305	100	1039.3	1,328	0	307.9
P128	156,314	68	751.4	154,474	68	621.8	1,840	0	129.6
P129	104,524	45	486.5	103,110	45	417.9	1,414	0	68.6
P143	104,524	45	486.5	103,110	45	417.9	1,414	0	68.6
P501A	178,690	64.7	0	169,048	58.7	0	9,642	6	0
P501B	70,571	30.3	332.9	70,087	30.2	265.6	484	0.1	67.3
P502	141,270	52.1	0	132,399	46.9	0	8,871	5.2	0
P503	52,110	23	297.5	51,907	23	243.3	203	0	54.2
P504	43,439	19	241.1	43,149	19	195.8	290	0	45.3

TABLE 3-7
ECO #9: ANNUAL ENERGY USE DATA

Bldg. No.	Baseline			ECO (Grey and Bronze Glass)			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P501A	178,690	64.7	0	169,612	57.3	0	9,078	7.4	0
P502	141,270	52.1	0	132,812	45	0	8,458	7.1	0

TABLE 3-8
ECO #9: ECONOMIC SUMMARY

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$/yr)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
CLEAR GLASS							
P100	(189)	0	439	57,602	0	256.0	0.1
P102	6	0	95	27,622	0	305.0	0.1
P124	83	0	734	102,092	0	149.0	0.1
P128	115	0	287	72,187	0	200.0	0.1
P129	89	0	152	37,866	0	176.0	0.1
P143	89	0	152	37,866	0	176.0	0.1
P501A	213	1,404	0	39,008	0	26.9	0.6
P501B	11	39	149	27,507	0	154.4	0.1
P502	196	1,209	0	26,747	0	21.2	0.7
P503	13	0	120	40,750	0	342.0	0.1
P504	18	0	100	32,969	0	310.0	0.1
GREY AND BRONZE GLASS							
P501A	213	1,736	0	42,361	0	24.2	0.6
P502	187	4,680	0	29,046	0	17.5	0.8

Unit electrical energy price: \$0.0627/kWh for all but P501A and P502.
\$0.0221/kWh for P501A and P502.
Unit electrical demand price: \$0/kW for all but P501A and P502.
\$19.5 /kW for P501A and P502.
Unit gas energy price: \$2.2124/MBtu

Conclusions: Replacement windows are not cost effective on any of the designated buildings. The combination of very low natural gas prices and low number of heating degree days does not produce sufficient savings to amortize the cost of construction over the 25 year life of the windows.

3.6 ECO #10: INSTALL INSTANTANEOUS POINT-OF-USE WATER HEATERS IN TOILETS, SHOWERS AND JANITOR CLOSETS

Background: Twenty-three buildings are designated in Section 3.1 for evaluation. The existing domestic hot water systems are of two types: nonrecirculating and circulating. Most of the buildings have one or two 40 gallon residential type water heaters that supply the toilets and janitor closets through well-insulated pipes. The other buildings have hot water storage tanks that are charged by either a boiler or by several 40 gallon residential type water heaters. These systems have supply and return piping and recirculating pumps. The conversion to electric point-of-use heaters will eliminate heat loss from storage, supply pipes, and return pipes. Conversion will improve heat source efficiency, but will add to the base electrical energy use, and in some cases to the electrical demand.

In the case of P236, the gymnasium, point-of-use heaters are not practical. There are times during the month when the locker room facilities are used by up to 100 persons at once. This places a very large load on the hot water system. A technical analysis of the retrofit was made, and the energy cost savings were calculated, but no cost estimate for the conversion was made because the conversion is impractical. It would require increased building electric service, new electric panel, new wiring, and piping changes. The existing gas-heated hot water system with 1,375 gallon storage is the best choice for the building.

ECO #10 has no practical application for P1621, the photographic laboratory. Photographic processing requires large amounts of hot water daily, and the existing gas-heated domestic water system serves the processes, restrooms and service sinks. An analysis was made, but the energy savings were negative. It is impractical and not cost effective to replace the existing system with point-of-use electric heaters.

Method of Analysis: Hand calculations for each building were made based on the heat loss equations developed in Appendix D, Tab 4 in Volume I Book 2. In the case of the gymnasium the heating load will add to the base electric demand. The cost savings were calculated using \$0.0221/kWh, and \$19.50/kW. The natural gas unit price used is \$2.2124/MBtu.

Results:

TABLE 3-9
ECO #10: ANNUAL ENERGY USE DATA

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P102	545	0.063	48.60	4,969	0	0	(4,424)	0	48.60
P124	1,666	0.063	50.34	5,825	0	0	(4,159)	0	50.34
P153	0	0	12.87	812	0	0	(812)	0	12.87
P236	NOT FEASIBLE								
P254	0	0	25.59	2,121	0	0	(2,121)	0	25.59
P260	0	0	17.24	1,579	0	0	(1,579)	0	17.24
P300	1,665	0.189	116.27	12,693	0	0	(11,026)	0	116.27
P380	0	0	12.27	270	0	0	(270)	0	12.27
P464	0	0	15.54	1,896	0	0	(1,896)	0	15.54
P1504	0	0	43.15	4,515	0	0	(4,515)	0	43.15
P1506	0	0	106.2	5,828	0	0	(5,828)	0	106.2
P1512	0	0	40.01	768	0	0	(768)	0	40.01
P1526	0	0	22.1	4,515	0	0	(4,515)	0	22.1
P1528	0	0	48.75	4,515	0	0	(4,515)	0	48.75
P1530	0	0	80.32	10,161	0	0	(10,161)	0	80.32
S1558	0	0	26.14	3,205	0	0	(3,205)	0	26.14
P1621	NOT FEASIBLE BECAUSE OF PHOTO PROCESSING								
P1622	0	0	59.57	4,515	0	0	(4,515)	0	59.57
P1624	0	0	59.26	5,839	0	0	(5,839)	0	59.26
P1751	545	0.063	23.23	1,128	0	0	(583)	0	23.23
S1753	0	0	12.31	768	0	0	(768)	0	12.31
S1790	0	0	31.56	768	0	0	(768)	0	31.56
S1794	0	0	18.4	1,400	0	0	(1,400)	0	18.4

**TABLE 3-10
ECO #10: ECONOMIC SUMMARY**

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
P102	(98)	0	108	7,820	0	892	0.1
P124	(14)	0	111	16,158	0	928	0.1
P153	(18)	0	29	2,314	0	243	0.1
P236	NOT FEASIBLE						
P254	(47)	0	57	4,628	0	529	0.1
P260	(35)	0	38	3,830	0	1,383	0.1
P300	(244)	0	257	20,826	0	1,704	0.1
P380	(6)	0	27	7,620	0	401	0.1
P464	(42)	0	34	4,588	0	N/A	N/A
P1504	(100)	0	95	3,830	0	N/A	N/A
P1506	(20)	0	106	9,176	0	96	0.3
P1512	(17)	0	89	8,458	0	132	0.2
P1526	(100)	0	49	6,104	0	N/A	N/A
P1528	(100)	0	108	6,234	0	858	0.1
P1530	(225)	0	178	12,408	0	N/A	N/A
S1558	(71)	0	58	7,666	0	N/A	N/A
P1621	NOT FEASIBLE BECAUSE OF PHOTO PROCESSING						
P1622	(100)	0	132	12,378	0	431	0.1
P1624	(130)	0	131	10,892	0	7,395	0.1
P1751	(13)	0	51	2,324	0	67	0.3
S1753	(17)	0	27	2,314	0	251	0.1
S1790	(17)	0	70	2,334	0	49	0.4
S1794	(31)	0	41	12,374	0	1,411	0.1

Conclusions: The gas energy cost savings are not sufficient to offset the high cost of electricity, and the proposed conversion is not cost effective in any of the buildings. The efficiency of the existing systems is quite good, and the insulation of hot water pipes and storage tanks is excellent in all the buildings surveyed. The existing gas-fired systems are a good choice for the WSMR.

3.7 ECOs #12 & #13: REPLACE EXISTING LIGHT FIXTURES WITH MORE EFFICIENT EQUIPMENT

Background: ECOs 12 and 13 are essentially the same. ECO #13 specifically addresses fluorescent lighting systems. Both are analyzed as one ECO since they apply to the same designated buildings.

Lighting systems energy conservation is widely practiced at the WSMR. In most buildings the number of active fixtures has been reduced by disconnecting fluorescent lamps and ballasts, or by removing incandescent lamps. In general illumination levels are not excessive, and further significant reductions are not practical.

Several fluorescent lighting technologies were considered in deciding on a replacement concept:

- install reflectors in existing fixtures and delamp as appropriate.
- install reduced wattage lamps and reduced wattage induction ballasts.
- install triphosphor lamps with high frequency, electronic ballasts.

The reflector concept was discarded because of reported problems at government installations. In spite of manufacturers' claims, overall illumination is reduced by up to 40%, and subsequent ballast replacement may require significantly more labor hours than for a standard fixture without reflectors.

The cost effectiveness of triphosphor lamps with high frequency, electronic ballasts was checked on two buildings and found to be less than for reduced wattage lamps and ballasts. Also, the triphosphor lamps and high frequency electronic ballasts are not commonly available in the federal supply system, so future supplies are questionable.

In view of the above considerations, the approach taken in the application of this ECO was to replace existing standard fluorescent lamps and ballasts with energy efficient (reduced wattage) lamps and ballasts in those areas where illumination is adequate. In other areas adequately illuminated by incandescent or mercury vapor lamps, higher efficiency fixtures with equal illumination and equal color characteristics were considered.

Energy savings will accrue from the reduced consumption of the lighting equipment. None of the designated buildings are air-conditioned. A very small increase in heating source energy will occur because of the reduction in internal gains from the reduced lighting wattage, but is insignificant. Fan energy consumption of evaporative coolers is not affected.

Method of Analysis: Hand calculations were made for each designated building, and are included with other backup data in Appendix D, Tab 5 in Volume I Book 2.

Results:

TABLE 3-11
ECOs #12 & #13: ANNUAL ENERGY USE DATA

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P1743	89,238	40.4	0	54,282	24.6	0	34,956	15.8	0
P1751	43,214	19.6	0	32,094	14.5	0	11,121	5.0	0
P1753	18,493	8.4	0	10,615	4.8	0	7,789	3.6	0
P1790	95,238	43.1	0	78,528	35.5	0	16,710	7.6	0
P1794	71,286	32.3	0	31,705	14.3	0	39,581	17.9	0
P1830	54,110	24.5	0	40,724	18.4	0	13,386	6.1	0
P1845	1,273	0.6	0	942	0.4	0	332	0.2	0

TABLE 3-12
ECOs #12 & #13: ECONOMIC SUMMARY

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
P1743	773	3,701	0	26,824	0	6.7	2.2
P1751	246	1,177	0	9,515	0	7.5	2.0
P1753	174	834	0	7,396	0	8.2	1.8
P1790	369	1,769	0	9,643	0	5.0	2.9
P1794	875	4,191	0	24,962	0	5.5	2.7
P1830	296	1,417	0	12,211	0	8.0	1.9
P1845	7	35	0	281	0	7.4	2.0

Unit electrical energy price: \$0.0221/kWh

Unit electrical demand price: \$19.50/kW

Unit gas energy price: \$2.2124/MBtu

Conclusions: The SIRs shown above include all energy and nonenergy cost savings (electric demand cost savings). The ECO fails the project nonenergy test for ECIP projects, in that when the nonenergy cost savings are restricted to 33% of the energy cost savings, the SIRs are approximately 0.6. However, for nonECIP projects the 33% restriction does not apply, and

the improved lighting is recommended for the seven listed buildings, to be funded by OMA or other funds.

3.8 ECO #17: REPLACE EXISTING GAS-FIRED HEATING EQUIPMENT WITH GAS-FIRED INFRARED OR RADIANT HEATERS IN HIGH BAY AREAS

Background: All of the designated buildings have high bay areas, are equipped with large overhead doors, and overhead cranes for moving equipment. For each designated building, it is feasible to install infrared (IR) heaters so as not to interfere with existing mission equipment and lighting fixtures. Most of the designated buildings are equipped with gas-fired unit heaters that hang in the upper regions of the high bays, and have flue pipes that penetrate the roofs. Gas lines are existing, and are adequately sized.

Energy savings will accrue from reduced infiltration heat loss (IR heaters heat the floor, walls and equipment, but not the air), from reduced wall, window and roof losses because room air temperatures will be about 4 to 5 degrees below the existing thermostat setpoints, and from the improved Annual Fuel Use Efficiency (AFUE) of 85% for noncondensing gas-fired IR heaters versus 75% for unit heaters.

The WSMR has a very short heating season, and winter afternoon ambient temperatures often rise above 60°F. In practice, existing unit heaters run many hours when the ambient temperature is above the crossover temperatures for the buildings. Internal gains (mostly lights), coupled with solar heat gains frequently offset all heat losses down to ambient temperatures of approximately 45°F. This tends to reduce the annual energy savings of IR heaters, and lengthens the payback period.

Method of Analysis: Building energy consumption was calculated using the TRACE 600 program. The baseline runs use a space thermostat setting of 65°F, unit heater AFUE of 75%, and rates of infiltration appropriate for the individual building. The ECO runs use a space thermostat setting of 60° to 61°F, an IR heater AFUE of 85%, and reduced infiltration rates.

The TRACE 600 program is unable to simulate the effects of directly radiating the floor and room equipment, and the subsequent heating of the room air by the floor and equipment. It does not simulate the reduction in temperature stratification that is achieved by IR heaters. These program deficiencies are compensated for in the ECO runs by reducing infiltration rates and space thermostat setpoints.

Each building has several large overhead doors, and the infiltration rate is a significant component of the building heat loss. The infiltration rate for each building was estimated at the time of the survey, after discussing the operation of the building with the building manager.

TRACE 600 output reports and other ECO backup data are found in Appendix D, Tab 6 in Volume I Book 2.

Results:

TABLE 3-13
ECO #17: ANNUAL ENERGY USE DATA

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P1550	43,657	20	285.1	39,676	18	158.1	3,981	0	127
P1554	43,657	20	285.1	39,676	18	158.1	3,981	0	127
P1644	25,758	12	136.4	24,193	11	76.1	1,565	0	60
S1680	77,447	34	544.5	76,678	34	305.4	769	0	239
P1751	34,921	15	521.6	34,243	15	300.4	678	0	221
S1753	17,107	8	204.9	16,738	8	115.4	369	0	90
P1788	42,426	18	246.9	42,013	18	136.5	413	0	110
P1794	64,742	28	838.1	63,140	28	474.2	1,602	0	364
P1827	23,927	10	553.0	23,627	10	328.1	300	0	225
P1833	36,401	16	285.1	36,064	16	169.1	337	0	116

TABLE 3-14
ECO #17: ECONOMIC SUMMARY

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
P1550	250	0	281	10,313	0	18.0	0.6
P1554	250	0	281	10,313	0	18.0	0.6
P1644	98	0	133	3,873	0	13.9	0.8
S1680	48	0	529	10,530	0	20.3	0.6
P1751	43	0	490	10,584	0	11.7	1.0
S1753	23	0	198	6,793	0	14.4	0.8
P1788	26	0	244	5,677	0	10.3	1.1
P1794	100	0	805	14,600	0	9.7	1.2
P1827	19	0	498	10,695	0	11.5	1.0
P1833	21	0	257	8,268	0	13.8	0.8

Unit electrical energy price: \$0.0627/kWh

Unit electrical demand price: \$0/kW

Unit gas energy price: \$2.2124/MBtu

Conclusions: It is economically feasible to install gas-fired infrared (IR) heaters in three of the designated buildings. Buildings P1788, P1794, and P1827 have an SIR greater than 1.0, which justifies conversion.

3.9 ECOs #19 & #20: INSTALL THERMOSTATICALLY CONTROLLED RADIATOR/CONVECTOR VALVES (MODIFY HEATING CONTROLS)

Background: Building P100 is equipped with low pressure steam, finned tube convectors mounted beneath windows along exterior walls. The convectors are equipped with self-contained, automatic thermostatic control valves, which appear to be in good operating condition. Even so, most of the spaces in both buildings are somewhat overheated, especially from about 0900 hours to 1300 hours. There are no other heating controls in the buildings.

The winter space heating load changes rapidly in the morning when occupants arrive and the lights are turned on. Also, the outdoor temperature rises rapidly in the morning. Early morning winter temperatures vary from the upper thirties to the low forties, but increase to 50 degrees or above by 1000 hours. This temperature is above the heating crossover temperature of approximately 45 degrees for Building P100. The impact of these rapid changes is that by about 0930 to 1000 hours, the building needs little or no heat, and the convectors cannot respond quickly enough to maintain the set temperatures. The existing self-

contained thermostatic control valves appear to be functioning properly, but even so, the building overheats. The usual response of the occupants is to close the radiator control valves, and sometimes to open windows. On the average, the space temperatures on the day of the survey (1100 hours, 5 November '91) were about 76°F instead of 68°F to 70°F.

From the practical engineering point-of-view, nothing can be done to control the supply of steam to prevent the temperature overshoot in the building. The supply of steam is either on or off. The finned tube convectors are not suitable for conversion of the system to hot water. A water system would require the installation of longer finned tube elements, which is too costly to be feasible.

One feasible solution is to replace all the self-contained thermostatic control valves with valves controlled by wall-mounted thermostats. The existing thermostatic control valves are approximately 20 inches above the floors. Mounting new thermostats on the walls at a height of about 5 feet would help reduce the effect of thermal stratification, which does exist to some degree in the building.

The concept for this ECO for P100 is to replace the existing thermostatic valves with control valves and wall-mounted thermostats. It is assumed in the analysis that this will enable room temperatures to be properly controlled.

Building P124 is equipped with hot water finned tube baseboard convectors and a hot water boiler. The building overheats when occupied. The supply hot water temperature is constant, and is manually set on the boiler. The boiler is activated when outdoor temperatures are below 58°F. There are no zone valves or zone hot water temperature reset controls in the building, however, the piping system provides for one network to supply the north side of the building, and one to supply the south side.

The following heating control modifications to P124 are proposed:

1. Install a hot water temperature reset control on the boiler, and three space thermostats at points along the north wall perimeter. Install a controller (comparator type) to select the highest demand for heat and reset the water temperature accordingly. A reset schedule of 220°F at 20°F ambient and 120°F at 60°F ambient is suggested.
2. Install a 3-way mixing valve on the supply and return piping for the south network. Install 3 space thermostats on the south perimeter and a controller to reset the loop temperature to satisfy the peak heating load.

These modifications will ensure adequate supply water temperature to the north exposure, while providing a reduced water supply temperature to the south exposure which has high solar gains. In overcast conditions both water supply loops would be at the same temperature.

The only other alternative to these proposed modifications is to replace the existing radiator valves (isolation valve) on the 28 radiators on the south exposure with a control valve and wall thermostat. This is a very expensive retrofit, and would still require a boiler water temperature reset controller. This is not recommended.

Method of Analysis: TRACE 600 is used to establish the energy consumption for both the baseline and retrofit configurations. The baseline models use a 76°F space temperature setting, and the ECO models use 70°F. Backup data is included in Appendix D, Tab 7 in Volume I Book 2.

Results:

TABLE 3-15
ECOs #19 & #20: ANNUAL ENERGY USE DATA

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P100	307,184	146	1,683.9	303,102	146	858.4	4,082	0	825.5
P124	206,633	100	1,450.8	204,363	100	711.2	2,270	0	739.6

TABLE 3-16
ECOs #19 & #20: ECONOMIC SUMMARY

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
P100	256	0	1,826	12,071	0	6.5	1.9
P124	142	0	1,636	5,191	0	3.3	3.8

Unit electrical energy price: \$0.0627/kWh

Unit electrical demand price: \$0/kW

Unit gas energy price: \$2.2124/MBtu

Conclusions: It is cost effective to revise the heating controls on both P100 and P124, and it is recommended for both buildings.

3.10 ECO #29: INSTALL A STEAM BOOSTER HEATER ON THE DISHWASHER IN BUILDING P1330

Background: The dish washer in the Officers Club kitchen was inspected and the manufacturer's catalog and installation guide were also reviewed. The catalog and installation guide show electrical heating coils on the wash and rinse water cycles without a steam preheater, but in fact, a steam preheater is already installed. The club manager reported that the rinse and wash temperatures reach 160°F as required, and from the water heating aspect, the dishwasher works quite adequately. Whereas an additional steam preheater might shift

some of the heating load from electricity to steam, the source energy consumption would increase.

Method of Analysis: None performed.

3.11 ECO #30: INSTALL A BOILER FOR SUMMER DOMESTIC HOT WATER HEATING IN BUILDING P236, GYMNASIUM

Background: The gymnasium is equipped with a 1,375 gallon hot water storage tank that is charged by the space heating boiler in winter, and by two 40 gallon gas-fired hot water heaters in summer. The 40 gallon heaters have adequate makeup rate to maintain the storage tank temperature between 130°F and 160°F. A mixing valve at the tank provides approximately 130°F water at the sinks and showers. A summer boiler would replace the two 40 gallon heaters, and operate at an AFUE of approximately 75%. The existing heaters also have an AFUE of about 75%. As it is, the existing system provides an additional 80 gallons of storage. The proposed ECO has little to offer in system improvement, and would never payback. Maintenance costs are less for the existing system than for a smaller boiler.

Method of Analysis: None performed.

Note: The existing boiler failed in 1992 and was replaced in the summer of 1992.

3.12 SUMMARY OF GENERAL ECO EVALUATIONS

Table 3-17 on the following pages presents the results of each ECO evaluation.

TABLE 3-17
GENERAL ECO EVALUATION SUMMARY

ECO #	Bldg. #	Annual Energy Savings			Demand Savings (kW)	Annual Energy Cost Savings			Construction Cost (\$)	SPB	SIR
		Elec. (kWh)	Gas (MBtu)	Total (MBtu)		Elec. (\$)	Demand (\$)	Gas (\$)			
2	T117	141	45.1	45.6	0	9	0	100	1,450	14.9	1.3
4	P1782	Not Evaluated									
4	P1830	(612)	69.0	66.9	(1)	(38)	0	152	93,109	124.9	0.1
7	P160	Not Evaluated									
9	P100	(3,010)	198.5	188.2	0	(189)	0	439	57,602	256.3	0.1
9	P102	99	42.8	43.1	0	6	0	95	27,662	305.2	0.1
9	P124	1,328	307.9	312.4	0	83	0	681	102,092	149.0	0.1
9	P128	1,840	129.6	135.9	0	115	0	287	72,187	200.1	0.1
9	P129	1,414	68.6	73.4	0	89	0	152	37,866	175.6	0.1
9	P143	1,414	68.6	73.4	0	89	0	152	37,866	175.6	0.1
9	Clear P501	9,642	0	32.9	6	213	1,404	0	39,008	26.9	0.6
9	P502	8,871	0	30.3	5.2	196	1,209	0	26,747	21.2	0.7
9	P503	203	54.2	54.9	0	13	0	120	40,750	342.5	0.1
9	P504	290	45.3	46.3	0	18	0	100	32,969	310.4	0.1
9	Grey 501A	9,078	0	31	7.4	213	1,736	0	42,361	24.2	0.6

TABLE 3-17 (Continued)
GENERAL ECO EVALUATION SUMMARY

ECO #	Bldg. #	Annual Energy Savings			Demand Savings (kW)	Annual Energy Cost Savings			Construction Cost (\$)	SPB	SIR
		Elec. (kWh)	Gas (MBtu)	Total (MBtu)		Elec. (\$)	Demand (\$)	Gas (\$)			
9	Clear 501B	484	67.3	69	0.1	11	39	149	27,507	154.4	0.1
9	Grey 502	8,458	0	28.9	7.1	187	1,658	0	29,046	17.5	0.8
10	P102	(4,424)	48.6	33.5	0	(98)	0	108	7,820	892	0.1
10	P124	(4,159)	50.3	36.1	0	(14)	0	111	16,158	927	0.1
10	P153	(812)	12.9	10.1	0	(18)	0	29	2,314	243.1	0.1
10	P236	Not Feasible									
10	P254	(2,121)	25.6	18.4	0	(47)	0	57	4,628	529.2	0.1
10	P260	(1,579)	17.2	11.8	0	(35)		38	3,830	1383	0.1
10	P300	(11,026)	116.3	78.7	0	(244)	0	257	20,826	1,704.1	0.1
10	P380	(270)	12.3	11.4	0	(6)	0	27	7,620	400.8	0.1
10	P-464	(1,896)	15.5	9.0	0	(42)	0	34	4,588	N/A	N/A
10	P1504	(4,515)	43.2	27.8	0	(100)	0	95	3,830	N/A	N/A
10	P1506	(5,828)	106.2	86.3	0	(20)	0	106	9,176	96	0.3
10	P1512	(768)	40.0	37.4	0	(17)	0	89	8,458	131.8	0.16

TABLE 3-17 (Continued)
GENERAL ECO EVALUATION SUMMARY

ECO #	Bldg. #	Annual Energy Savings			Demand Savings (kW)	Annual Energy Cost Savings			Construction Cost (\$)	SPB	SIR
		Elec. (kWh)	Gas (MBtu)	Total (MBtu)		Elec. (\$)	Demand (\$)	Gas (\$)			
10	P1526	(4,515)	22.1	(6.7)	0	(100)	0	49	6,104	N/A	N/A
10	P1528	(4,515)	48.8	33.4	0	(100)	0	108	6,234	857.7	0.1
10	P1530	(10,161)	80.3	45.6	0	(225)	0	178	12,408	N/A	N/A
10	S1558	(3,205)	26.1	15.2	0	(71)	0	58	7,666	N/A	N/A
10	S1621	Not Feasible									
10	P1622	(4,515)	59.6	44.2	0	(100)	0	132	12,378	430.6	0.1
10	P1624	(5,839)	59.3	39.4	0	(130)	0	131	10,892	7394.5	0.1
10	P1751	(583)	23.2	21.2	0	(13)	0	51	2,324	67	0.3
10	S1753	(768)	12.3	9.7	0	(17)	0	27	2,314	251.2	0.1
10	S1790	(768)	31.6	29.0	0	(17)	0	70	2,334	49.2	0.4
10	P1794	(1,400)	18.4	13.6	0	(31)	0	41	12,374	1410.7	0.1
12-13	P1743	34,956	0	119.3	15.8	773	3,701	0	26,824	6.7	2.2
12-13	P1751	11,121	0	38.0	5.0	246	1,177	0	9,515	7.5	2.0
12-13	S1753	7,789	0	26.6	3.6	174	834	0	7,396	8.2	1.8
12-13	S1790	16,710	0	57.0	7.6	369	1,769	0	9,643	5.0	2.9
12-13	P1794	39,581	0	135.1	17.9	875	4,191	0	24,962	5.5	2.7

TABLE 3-17 (Continued)
GENERAL ECO EVALUATION SUMMARY

ECO #	Bldg. #	Annual Energy Savings			Demand Savings (kW)	Annual Energy Cost Savings			Construction Cost (\$)	SPB	SIR
		Elec. (kWh)	Gas (MBtu)	Total (MBtu)		Elec. (\$)	Demand (\$)	Gas (\$)			
12-13	P1830	13,386	0	45.7	6.1	296	1,417	0	12,211	7.9	1.9
12-13	P1845	332	0	1.1	0.2	7	35	0	281	7.4	2.0
17	S1550	3,981	127.0	140.6	0	250	0	281	10,313	18.0	0.6
17	S1554	3,981	127.0	140.6	0	250	0	281	10,313	18.0	0.6
17	P1644	1,565	60.3	65.3	0	98	0	133	3,873	13.9	0.8
17	S1680	769	239.1	241.7	0	48	0	529	10,530	20.3	0.6
17	P1751	678	221.2	223.5	0	43	0	490	10,584	11.7	1.0
17	S1753	369	89.5	90.8	0	23	0	198	6,793	14.4	0.8
17	P1788	413	110.4	111.8	0	26	0	244	5,677	10.3	1.1
17	P1794	1,602	363.9	369.4	0	100	0	805	14,602	9.7	1.2
17	P1827	300	224.9	225.9	0	19	0	498	10,695	11.5	1.0
17	P1833	337	116.0	117.2	0	21	0	257	8,268	13.8	0.8
19-20	P100	4,082	825.5	839.4	0	256	0	1,826	12,071	6.5	1.9
19-20	P124	2,270	739.6	747.3	0	142	0	1,636	5,191	3.3	3.8
29	P1330	Not Evaluated									
30	P236	Not Evaluated									

3.13 SUMMARY OF NONAPPLICABLE ECOs

Certain of the general ECOs were determined to be nonapplicable to certain buildings. This section lists the ECOs and buildings.

ECO #2 - Add roof insulation to Building P1830: The roof was recently replaced with an R-19 insulation rating.

ECO #4 - Lower ceilings in Building 1782: The building ceilings are 9 ft 4 in. now, and lowering to 8 ft will show no energy savings. In addition, the change would require new fluorescent fixtures and changes to the supply air ductwork. P1782 is not a candidate for lowered ceilings from the energy savings point of view.

Lower ceilings in Building P1530: This building has low ceilings except in two interior hallways that have no exposure to the building envelope. No energy will be saved by lowering the ceilings, so the building is not a candidate for this ECO.

ECO #7 - Install air curtains at Building P160: P160 already has air curtains installed that are operational. They are installed incorrectly and need to be moved to the exterior walls. A work order has been written to move the units.

ECO #10 - Install point-of-use water heaters in P236: The gymnasium domestic hot water system experiences very heavy use during on-peak electrical use periods. The domestic hot water connected kW load would increase by 345 kW, which is several times the existing demand. It is impractical for reasons of physical feasibility as well.

Install point-of-use water heaters in P1621. This building has a high daily use of hot water for photo processes, and one hot water system supplies the toilets, service sinks and the processing labs. The electric power draw on a point-of-use heater for the labs would be excessive for the existing electric service, and was not evaluated.

ECO #29 - Install steam booster heater on the dishwasher in Building P1330: A steam booster heater is already in place and no energy will be saved by installing another one.

ECO #30 - Install a summer domestic hot water boiler in Building P236: The 1,375 gallon storage is charged in winter by the space heating boiler, and in summer by two 40 gallon hot water heaters. The existing system provides adequate charging of the storage tank and is sufficient. A summer boiler would not provide energy savings or improve the system.

SECTION 4.0

EVALUATION OF ECOs FOR BUILDING P300

4.1 GENERAL

Building P300 is the Range Control building. It houses mission elements that control the various flight tests and other missile range mission activities. The building essentially has two types of spaces: administrative or offices, and mission equipment rooms which include various kinds of computers, display boards and scopes, control equipment, communications equipment and support equipment, such as printers, disk drives, etc. The building has two stories with a full basement and is U-shaped with a south wing (main building) and east and west wings.

The original mission equipment utilized vacuum tube and transistor technologies. Equipment heat gains to the spaces were relatively high. Consequently, the building was designed with two types of air handling and distribution systems. Most spaces are served by single zone air handling units (SZUs) that supply mechanically cooled air to raised floor plenums. The SZUs were sized to carry the equipment cooling load of the building. All spaces are served by a dual duct system (labeled as multizone units (MZUs) in the mechanical equipment rooms). Space thermostats are connected to mixing boxes to provide occupant control over room temperatures.

In essence the office spaces throughout the three wings are overcooled. The dual duct systems are intended to provide heat as needed, or extra cooling for equipment rooms during times of high mission activity.

Because various missions at the WSMR are either changed or eliminated from time to time, and new missions are occasionally added, it is necessary to maintain complete flexibility in controlling room temperatures in all areas of the building. Any proposed retrofit must provide for maximum flexibility for future changes.

The main building mechanical equipment room contains two centrifugal chillers, two SZUs, one large MZU, one hot water boiler and one small steam boiler to serve humidifiers in the SZU units. The east and west wing mechanical rooms each contain a hot water boiler, a SZU to serve the under floor air plenums, and a MZU for comfort conditioning. Six air-cooled chillers are located outside in the area between the east and west wings to give a total of 805 tons of mechanical cooling. All chillers are interconnected to provide maximum chilled water system reliability.

The building peak cooling load currently varies from about 44 tons in January to approximately 210 tons in July. The installed chillers range from 50 ton units to a 200 ton centrifugal, which provides flexibility and high availability in meeting the cooling loads. During most of the year, the 200 ton centrifugal chiller in the main building is on line. During high building cooling loads, one of the two McQuay 100 ton units is also brought on line. The other chillers (4 packaged air-cooled units) are used for maintenance standby as required, and may be used in periods of low load.

4.2 DISCUSSION OF ECOs

The Scope of Work requires the evaluation of eight ECOs (see Appendix A):

- Use more efficient lighting fixtures.
- Reduce lighting levels.
- Use recovered waste heat.
- Use dry bulb economizers.
- Reduce outside air quantities.
- Use thermal storage for demand reduction.
- Convert constant volume air handling systems to variable air volume.
- Consolidate multiple air-cooled chiller (loads) onto two high efficiency, water-cooled chillers.

4.2.1 Lighting Systems

Except for a small number of spot incandescent lights used infrequently during selected mission activities, the lighting in Building P300 is a mixture of standard and reduced wattage fluorescent lamps and ballasts. Reduced lighting energy conservation is already practiced in most areas of the building. Approximately one third of the lighting fixtures have been disconnected. Further reductions would result in inadequate lighting. It is feasible to convert all fluorescent fixtures to low wattage ballasts and lamps.

4.2.2 Waste Heat

Each wing is equipped with a hot water boiler and two 40 gallon domestic water heaters. The boilers serve the heating coils in the MZUs, and operate continuously. A single low pressure steam boiler in the south wing provides humidification for that wing, but is not in use. There may be potential for using recovered heat from chiller condensers to offset the boiler hot water loads.

4.2.3 Ventilation and Economizers

The east and west wings have less than 100 occupants on an average work day. The main building has approximately 120 occupants on an average day. Minimum required makeup air is about 1000 cfm for the east and west wings, and about 1800 cfm for the main building. In the main building makeup air dampers are located at the top of a large vertical return air shaft that runs from the top of the second floor to the basement. The shaft is actually a large mixed air plenum that serves the MZU and two SZUs in the basement mechanical room. It is possible to install an economizer control to control the mixed air plenum temperature but major modifications to the shaft are required to do so. The east and west wings receive a fixed amount of ventilation via the MZUs which supply all conditioned spaces. The SZUs have no fresh air intakes, and draw air only from the return air shafts. There are no economizer controls in the east and west wings, and substantial modifications to the make up air system are required to install economizers. A modification of the make up air system for

the building (3 wings) to support the installation of economizer controls would significantly relieve the chillers during the fall, winter and spring seasons.

4.2.4 Demand Side Management

The building is mechanically cooled 8,760 hours per year. Because the ambient air temperature is much lower at night than during the day, and because no solar loads exist at night, there is excess nighttime chiller capacity available to use for charging a chilled water storage tank. The thermal storage concept has potential application for Building P300. Fortunately, there is no demand ratchet clause in the electric utility contract, and a load shift for any month will result in demand charge savings for that month.

4.2.5 Conversion to Variable Volume Air Systems

The existing air systems are constant volume, and sized for the original design cooling loads for the building. The underfloor supply air registers and transfer ducts that currently supply office spaces would be capped off, and only the existing dual duct systems (MZUs) would supply the offices. This would make more air available to the computer and mission equipment rooms, thereby improving the capability of the SZUs to serve the equipment areas. Both the SZUs and the MZUs would be converted to VAV units with variable speed controllers. The proposed modification would reduce fan energy consumption, provide excellent flexibility in coping with future changes, and correct the problem of overcooling the offices.

Because all chillers are interconnected, and because no EMCS system exists, it is currently necessary to manually adjust the chilled water set point on all operating chillers. Depending on the weather conditions and the time of year, these adjustments may have to be made several times during a day. With VAV the chilled water set point could be relatively fixed, and supply air flow rates would be varied automatically to satisfy cooling loads in the most critical zones.

4.2.6 Consolidated Chilled Water Plant

The current operational practice is to operate the 200 ton centrifugal chiller most of the year, and to augment the cooling capacity with one or both of the 100 ton air-cooled chillers as needed. Four 50 ton air-cooled units are used for standby, and operate occasionally. All of the air-cooled chillers use more kW/ton for cooling than the centrifugal unit. The opportunity exists to improve the efficiency of the existing chiller plant by installing more water-cooled equipment. This should reduce electrical energy consumption and peak demand.

4.2.7 Contractor-Identified ECOs

A water-cooled reciprocating chiller with hot gas heat exchanger was evaluated as a chiller alternative in §4.7. The recovered heat would provide hot water for the 3 MZU hot deck heating coils, and building domestic hot water.

4.3 OPERATIONAL PRACTICES - HVAC

The mechanical systems in Building P300 are operated, serviced, and maintained by a contractor. Rapid variation of outdoor temperature in all seasons of the year coupled with widely fluctuating equipment user schedules, requires that supply air temperature setpoints and chilled water set points be reset throughout the day. Because the existing pneumatic control system has not historically been able to provide temperature control to the satisfaction of the occupants, the service contractor manually changes control settings to stabilize the operation of the air handlers and chillers. This policy has been successful in providing adequate temperature control throughout the building.

4.4 METHOD OF ANALYSIS OF APPLICABLE ECOs

The TRACE 600 building energy simulation program was used to simulate the existing building configuration, or baseline, and the designated ECOs. Each floor of each wing was zoned by office area and by mission equipment areas. See Appendix D, Tab 8 in Volume I Book 2, for zoning diagrams. Computer output reports, backup data, cost estimates and the LCCA forms are included in Appendix D, Tabs 8 through 14. The TRACE 600 baseline report is included in Tab 8.

4.5 ECO: IMPROVED LIGHTING FIXTURE EFFICIENCY

Background: At the time of the survey of Building P300, it was noted that energy conservation through the disconnection of fixtures is widely practiced. There is no natural light in the building, and most hallways have a low level of illumination. Many offices have some fixtures disconnected. Mission equipment rooms fall into two categories: rooms with normal office lighting requirements, and mission rooms in which only task lighting is used. In general, the lighting watts per square foot is not excessive in the sense that too many fixtures are in use. Discussions with building area managers and electric shop personnel indicate that the existing fluorescent fixtures are a mixture of standard and reduced wattage type. For evaluation purposes, it is assumed that one-third of the existing fluorescent fixtures are of the reduced wattage type. The ECO concept is to replace the standard lamps and ballasts with reduced wattage lamps and ballasts.

Method of Analysis: The baseline configuration lighting wattage was modified to obtain the impact of reduced wattage on both lighting and air-conditioning loads. See Appendix D, Tab 8 in Volume I Book 2, for the TRACE 600 output report.

Results:

TABLE 4-1
ANNUAL ENERGY USE DATA - LIGHTING

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P300	4,675,776	736.7	2,355	4,614,913	711.4	2,373	60,863	25.3	(18)

TABLE 4-2
ECONOMIC SUMMARY - LIGHTING

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
P300	1,345	5,909	(40)	38,783	0	6.0	2.5

Unit electrical energy price: \$0.0221/kWh

Unit electrical demand price: \$19.50/kW

Unit gas energy price: \$2.2124/MBtu

Conclusions: A retrofit to install low wattage fluorescent lamps and ballasts throughout P300 is economically justified, if both energy and all nonenergy cost savings are included.

4.6 ECO: REDUCED LIGHTING LEVELS

See §4.5 for a description of current lighting energy conservation practices. This ECO is not applicable, and was not evaluated.

4.7 ECO: WASTE HEAT RECOVERY

Background: The only uses of heat in Building P300 are hot water for heating coils in the three dual duct air handlers, and domestic hot water.

The only source of heat available is the heat of rejection from the building air-conditioning system. The existing chillers are not suitable for waste heat recovery retrofit.

This ECO assumes the replacement of one of the 2 existing 100 ton McQuay cold generators with a new 100 ton water-cooled reciprocating chiller with hot gas heat exchanger.

Method of Analysis: The central plant routine of the TRACE 600 program was used to simulate the performance of a reciprocating water-cooled chiller with heat recovery. The recovered heat was assigned to the hot water heating coils in the 3 MZUs. See Appendix D, Tab 9 in Volume I Book 2, for backup data.

Results:

**TABLE 4-3
ANNUAL ENERGY USE DATA - CHILLER WASTE HEAT RECOVERY**

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P300	4,675,776	736.7	2,355	4,565,370	705	124.5	110,406	31.9	2,231

**TABLE 4-4
ECONOMIC SUMMARY CHILLER WASTE HEAT RECOVERY**

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
P300	2,440	7,469	4,935	91,996	(1,000)	7.4	2.2

Unit electrical energy price: \$0.0221/kWh

Unit electrical demand price: \$19.50/kW

Unit gas energy price: \$2.2124/MBtu

Conclusions: The use of a desuperheater type heat recovery unit on a water-cooled reciprocating chiller resulted in considerable savings in cooling tower operation, and a large savings in boiler fuel. The total annual cost savings is approximately \$13,850, which makes the ECO cost effective. However, waste heat recovery is not as effective as a new water-cooled 100 ton chiller without heat recovery (\$4.12) and is not recommended.

4.8 ECO: DRY BULB ECONOMIZERS

Background: The main building is served by one large MZU and two SZUs. Each unit draws air from a large vertical concrete shaft at one end of the building, which acts as a return air

plenum. Return air ducts from each floor connect to the shaft, and a fresh air inlet is located in the roof at the top of the shaft. The fresh air is for ventilation only, and the inlet is too small to provide sufficient make up airflow for an economizer cycle. A portion of the shaft is occupied by a large supply air duct. There are no existing dry bulb economizer controls or modulating control dampers on the main building air handlers.

The east and west wings each are served by one MZU and one SZU. The MZUs have make up air ducts (18" x 18") just large enough to provide 1,100 CFM to 1,500 CFM for building ventilation. The balance of the air supply is drawn from large vertical return air shafts. The east wing requires 975 CFM for its 65 occupants, and the west wing requires 705 CFM for its 47 occupants. The make up air ducts are much too small to support an economizer cycle on the MZUs. The SZUs draw only return air, and are not configured for make up air. There are no existing economizer controls or modulating control dampers on air handlers in the east and west wing.

The application concept for this ECO is to make major changes to the vertical air shafts in each of the three buildings to provide for sufficient make up air and for relief of return air, so as to form a mixing chamber at the bottom of each shaft. In this way the chamber would be controlled at 55°F when ambient air temperatures permit. The economizer controls would be Direct Digital Control (DDC).

These changes require that the vertical shafts be partitioned, and that the return air be completely ducted. See Appendix D, Tab 10 in Volume I Book 2, for concept sketches, cost estimate and backup calculations.

Method of Analysis: The baseline condition was simulated on TRACE 600 using 7% makeup air dampers leakage as the makeup air rate. This exceeds the required minimum ventilation rate of 15 cfm per person. This ECO is evaluated using the TRACE 600 dry bulb economizer routine and zone load discriminator routine, with the makeup air damper at the minimum position at outdoor temperatures of 72°F and above. See Appendix D, Tab 10 in Volume I Book 2, for backup data.

Results:

**TABLE 4-5
ANNUAL ENERGY USE DATA - DRY BULB ECONOMIZERS**

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P300	4,675,726	736.7	2,355	4,281,456	706	4,499	394,270	30.8	(2,144)

TABLE 4-6
ECONOMIC SUMMARY - DRY BULB ECONOMIZERS

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
P300	8,713	7,196	(4,743)	149,536	0	14.9	0.7

Unit electrical energy price: \$0.0221/kWh

Unit electrical demand price: \$ 19.5/kW

Unit gas energy price: \$2.2124 MBtu

Conclusions: The use of a dry bulb economizer with a zone load discriminator offloads the chillers and cooling towers when ambient temperatures are below 72°F, but does require an increase in boiler fuel to heat the MZU hot decks which currently get mostly return air at about 74°F. The zone load discriminator minimizes the additional hot deck heating requirement. The high construction cost defeats the economic effectiveness of the significant energy cost savings of this ECO. It is not recommended for implementation.

4.9 ECO: REDUCED OUTDOOR AIR QUANTITIES

See background discussion in §4.8 on page 4-6. Since current practice is to operate the makeup air dampers in closed or near-closed position, this ECO concept has no application, and was not evaluated. The dry bulb economizer ECO includes the minimum rate of outdoor air from the ASHRAE ventilation standard.

4.10 ECO: THERMAL STORAGE

Background: Because nighttime cooling load is less than the daytime load, the excess chiller capacity could be used to charge a chilled water storage tank. The tank would provide cooling during daytime peak demand periods to reduce monthly peak electrical demand. The cooling towers and air-cooled condenser units operate most efficiently at night when the outdoor ambient temperature is lowest. This shifting of load not only reduces daytime peak demand, but gives an overall reduction in the average kW/ton for chiller operation.

El Paso Electric Company currently pays a rebate to customers that shift on-peak chiller compressor motor loads to the off-peak period. The rebate is \$190/kW based on the calculated annual design cooling load.

Method of Analysis: The TRACE 600 program provides a chilled water thermal storage simulation routine, which was used to evaluate this ECO. The chilled water tank was sized at 2,000 ton-hours and used to maximize nighttime loading of the chillers. See Appendix D, Tab 11 in Volume I Book 2, for backup data.

Results:

TABLE 4-7
ANNUAL ENERGY USE DATA - THERMAL CHILLED WATER STORAGE

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P300	4,675,776	736.7	2,355	4,741,504	567.7	2,355	(65,728)	169	0

TABLE 4-8
ECONOMIC SUMMARY - THERMAL CHILLED WATER STORAGE

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Utility Company Rebate (\$)	Simple Payback (yrs)	SIR
P300	(1,453)	39,546	0	165,000	\$54,788	4.6	3.3

Unit electrical energy price: \$0.0221/kWh

Unit electrical demand price: \$19.50/kW

Unit gas energy price: \$2.2124/MBtu

Conclusions: The use of thermal storage requires the chillers to produce 40°F chilled water, and requires more kW/ton than the usual 45°F chilled water operation. The result is an increase in source energy consumption of 224 MBtu/yr, a large savings in the average peak electrical demand of 169 kW, and an SIR of 3.3. A rebate of \$190/kW per average shifted compressor motor kW (288.4 kW at design peak load) was included as a nonrecurring cost saving in year number one of the life cycle cost analysis. The large reduction in peak demand and the utility rebate combine to make this a very effective ECO for Building P300.

4.11 ECO: VARIABLE AIR VOLUME

Background: The air systems were designed to handle high equipment heat gains in mission activity spaces. Over the years, most of the original mission equipment has been replaced with reduced wattage equipment. There have been no adjustments to fan supply air rates, although the supply air flow rates to various spaces have been adjusted many times. Most office areas are supplied by both the MZUs and the SZUs via underfloor plenums, which results in overcooling. This ECO considers the elimination of SZU supply air to the office areas, and the application of variable speed controllers on

all fans. This will reduce fan energy consumption, cooling coil loads, hot deck coil loads, and improve comfort conditions for office occupants.

Method of Analysis: The baseline TRACE 600 model was modified to incorporate VAV systems with variable speed control for SZUs and MZUs, and to assign office areas to only the MZUs. Office room thermostats control the MZU mixing boxes to maintain room temperature set points. See Appendix D, Tab 12 in Volume I Book 2, for backup data.

Results:

**TABLE 4-9
ANNUAL ENERGY USE DATA - VARIABLE AIR VOLUME**

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P300	4,675,776	736.7	2,355	3,472,254	645.5	1,585	1,203,522	91.2	770

**TABLE 4-10
ECONOMIC SUMMARY - VARIABLE AIR VOLUME**

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
P300	26,598	21,333	1,704	268,913	0	6.0	1.8

Unit electrical energy price: \$0.0221/KWh

Unit electrical demand price: \$19.50/kW

Unit gas energy price: \$2.2124/MBtu

Conclusions: The use of variable air volume in Building P300 appears to be cost effective, and practical. It will reduce annual electrical consumption by 4,108 MBtu, gas consumption by 770 MBtu, reduce on peak electrical demand by 91.2 kW, and pay for itself in 5 years. Perhaps most important, the use of VAV air flow will provide for adequate cooling of all mission equipment and simultaneous comfort of personnel, and provide flexibility for future changes in the use of spaces.

4.12 ECO: REPLACE EXISTING AIR-COOLED CHILLERS WITH WATER-COOLED CHILLERS

Background: The Range Control Building is served by 8 chillers. The main building (south) is equipped with one 165 ton and one 200 ton electric centrifugal chiller, each served by a cooling tower. Six air-cooled cold generators are located outside between the east and west wings. The normal sequence of chiller use is one of the two centrifugal units plus a single 50-ton air-cooled chiller, augmented by one of the two 100-ton air-cooled units as necessary.

A computer simulation of the building baseline cooling load indicates that the load varies from a low of approximately 44 tons in winter to a summer high of 210 tons. This was generally confirmed by discussions with Comfort Zone, Inc. personnel, who operate the building HVAC systems. Seldom are more than two chillers required to meet the load.

The existing 200 ton centrifugal is 10 years old and has approximately 13 years of remaining life. The existing 165 ton centrifugal chiller is original building equipment, and is used occasionally in place of the 200-ton unit. The concept for this ECO is to replace one of the two 100 ton air-cooled chillers with a new, 100 ton water-cooled reciprocating chiller to augment the existing 200 ton unit. The other 5 air-cooled chillers would be retained for backup. The 3 water-cooled chillers would be served by the two existing cooling towers.

Method of Analysis: The baseline TRACE 600 model includes the existing chilled water equipment in the plant portion of the program. The ECO is evaluated by incorporating chilled water equipment that includes the existing 200 ton centrifugal unit, the existing cooling towers, and a new water-cooled 100 ton reciprocating chiller. The TRACE 600 report, and other backup data are included in Appendix D, Tab 13 in Volume I Book 2.

The economic analysis accounts for the difference in maintenance and servicing costs between the baseline and modified configurations.

Results:

**TABLE 4-11
ANNUAL ENERGY USE DATA - CONSOLIDATED CHILLERS**

Bldg. No.	Baseline			ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
P300	4,675,776	736.7	2,355	4,489,721	698.2	2,355	186,055	38.5	0

TABLE 4-12
ECONOMIC SUMMARY - CONSOLIDATED CHILLERS

Bldg. No.	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
P300	4,112	9,009	0	56,100	(1,000)	5.2	2.9

Unit electrical energy price: \$0.0221/kWh

Unit electrical demand price: \$19.50/kW

Unit gas energy price: \$2.2124/MBtu

Conclusions: The performance advantage of water-cooled chillers over air-cooled cold generators is shown in this ECO evaluation. The very high ambient summer temperatures cause the compressors in an air-cooled unit to operate at high head pressure, whereas the cooling tower that services the water-cooled unit is very efficient in the dry New Mexico summer air. The annual savings of approximately \$13,000 justify this ECO.

4.13 SUMMARY OF RESULTS

The results of the ECOs applicable to Building P300 are summarized in Tables 4-13 and 4-14.

TABLE 4-13
ANNUAL ENERGY USE DATA - SUMMARY

	Purchased Utilities			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
Baseline	4,675,776	736.7	2,355	-	-	-
ECO: Lighting	4,614,913	711	2,373	74,589	25.3	(18)
ECO: Waste Heat Recovery	4,565,370	705	125	110,406	31.9	2,231
ECO: Economizers	4,281,456	706	4,499	394,270	30.8	(2,144)
ECO: Thermal Storage	4,741,504	567.7	2,355	(65,728)	169.0	0
ECO: VAV	3,472,254	645.5	1,585	1,203,522	91.2	770
ECO: Consolidated Chillers	4,489,721	698.2	2,355	186,055	38.5	0

**TABLE 4-14
ECONOMIC SUMMARY**

ECO #	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
Lighting	1,345	5,909	(40)	38,783	0	6.0	2.5
Waste Heat	2,440	7,469	4,935	91,996	(1,000)	7.4	2.2
Economizers	8,713	7,196	(4,743)	149,536	0	14.9	0.7
Thermal storage	(1,453)	39,546	0	165,000	0	4.7	3.3
VAV	26,598	21,333	1,704	268,913	0	6.0	1.8
Chillers	4,112	9,009	0	56,100	(1,000)	5.2	2.9

Improved lighting and VAV are not affected by the three chilled water system ECOs, but both impact the cost effectiveness of the proposed chilled water plant modifications.

The waste heat recovery ECO is not compatible with thermal storage or with the consolidated chiller plant ECO. The use of thermal storage would also reduce the cost effectiveness of the consolidated chiller plant ECO.

4.14 RECOMMENDATIONS

It is recommended that Building P300 be modified using ECIP funds to implement the lighting, VAV, thermal storage, and consolidated chiller plant ECOs. The new configuration is referred to as the modified configuration.

4.15 EVALUATION OF THE PROPOSED MODIFIED CONFIGURATION FOR P300

The energy use data for the modified configuration are presented in Table 4-15. Table 4-16 presents the economic parameters.

TABLE 4-15
ANNUAL ENERGY USE DATA

Configuration	Purchased Utilities			Elec. Energy Savings (kWh)	Average Demand Reduction (kW)	Gas Energy Savings (MBtu)
	Elec (kWh)	Elec (kW)	Gas (MBtu)			
Baseline	4,675,776	736.7	2,355	-	-	-
Modified configuration	3,285,543	636.0	1,612	1,390,333	317.8	743

TABLE 4-16
ECONOMIC SUMMARY

Configuration	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
Modified Configuration	30,723	28,538	1,644	446,296	(1,000)	4.7	2.3

The individual ECOs are backed out of the TRACE 600 model one at a time in order to determine the energy savings with the effects of interaction. The results are presented in Tables 4-17 and 4-18.

TABLE 4-17
ANNUAL ENERGY CONSUMPTION DATA OF ECOS WITH INTERACTION

Configuration	Purchased Utilities			Elec. Energy Savings (kWh)	Average Demand Reduction (kW)	Gas Energy Savings (MBtu)
	Elec (kWh)	Elec (kW)	Gas (MBtu)			
Modified Configuration	3,285,543	551.0	1,585	—	—	—
VAV	4,433,935	673.7	998	1,164,899	67.5	587
Chiller	3,460,157	617.6	1,585	179,015	18.0	0
Thermal Storage	3,279,396	599.6	1,585	(6,147)	48.6	0
Lighting	3,301,951	624.0	1,622	1,373,825	73.0	(37)

TABLE 4-18
ECONOMIC SUMMARY OF ECOs WITH INTERACTION

ECO	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
Modified Configuration	30,361	26,423	1,704	325,013	(1,000)	6.3	1.7
VAV	25,514	17,336	1,684	268,913	0	6.7	1.6
Chiller	3,995	4,212	0	56,100	(1,000)	8.7	1.7
Thermal Storage	(136)	25,019	0	82,500	0	3.7	2.9
Lighting	498	5,655	(61)	38,783	0	7.1	2.1

Each of the ECOs qualifies with an SIR > 1.0, and the modified configuration is recommended to be implemented as an ECIP project. The program documentation required under this contract is provided in Appendix C of this Volume 1 Book 1, and is discussed and summarized in Section 10.

SECTION 5.0

BUILDING ENERGY SURVEYS

5.1 GENERAL

Paragraph 4.4 of Annex B of the Scope of Work (see Appendix A) requires that building energy surveys be accomplished for Buildings P21140, P21695, and P24072. The buildings were surveyed to acquire the construction characteristics and equipment data required to calculate the baseline energy consumption. Survey data are included in Volume II, Building Survey Forms.

The buildings were modeled on the TRACE 600 program, and baseline and ECO energy consumption levels were obtained. Backup data and computer reports are included in Appendix D, Tabs 15, 16 and 17 in Volume I Book 2.

Each of the three buildings is a special purpose industrial building, with special safety requirements and operating restrictions. In the case of P21140, Temperature Test Facility, the design of the building mechanical systems requires all electric equipment. Gas-fired boilers are not acceptable in P21140. Building 21695 has four high bay areas that require low relative humidity. This requirement precludes the use of evaporative coolers, which would reduce energy consumption.

For each building, ECOs were considered in relation to the special mechanical system requirements for the various zones of the buildings, consistent with mission restrictions and requirements.

5.2 BUILDING 21140, TEMPERATURE TEST FACILITY

5.2.1 Description of Existing Conditions

The Temperature Test Facility houses two test bays, a small interior office, a large mechanical equipment room, and a high bay entrance area. The test bays operate on an irregular schedule, and are not included in the baseline energy model.

The design of the test bay conditioning equipment requires that a multi-stage electric boiler be used to provide heat. The fluid used in both the boiler and the test chamber chillers is a special, combustible, thermodynamic fluid. The fluid cannot be exposed to open flame, and gas-fired equipment is specifically excluded for the building. The unit heaters in the mechanical equipment room and in the high bay entrance area contain fan coil units served by the electric boiler.

The mechanical equipment room and the high bay entrance area are evaporatively cooled. A small packaged DX unit serves the interior office. It has a fluid-cooled condenser.

The lighting system consists of explosion-proof incandescent lights in the high bay entrance area, the test chambers, and in the mechanical equipment room. The office area is equipped with standard fluorescent lighting.

Domestic hot water is provided in two restrooms by small electric water heaters with approximately 1 gallon storage tanks.

Building survey notes are included in Volume II, Building Survey Forms.

5.2.2 Applicable ECOs

The high bay entrance area is currently stratified. Fan coil units are mounted high in the bay, and the natural convection of heat results in temperature stratification. ECO #1 is the installation of fans to decrease temperature stratification.

The office area is equipped with standard fluorescent lighting. ECO #2 is to replace the existing lamps and ballasts with reduced wattage lamps and ballasts.

5.2.3 Method of Analysis

The building baseline configuration was modeled on TRACE 600. The energy savings for both ECOs were hand calculated. (See Appendix D, Tab 15 in Volume I Book 2, for backup data.) The results are shown in Tables 5-1 and 5-2 below.

5.2.4 Results

Tables 5-1 and 5-2 present the results of the ECO analyses.

**TABLE 5-1
ANNUAL ENERGY USE DATA
Building 21140, Temperature Test Facility**

Building P21140				Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
Baseline	458,686	94	0	-	-	-
ECO #1: Stratification	454,949	94	0	3,737	0	0
ECO #2: Lighting	458,355	94	0	331	0.15	0

TABLE 5-2
ECONOMIC SUMMARY
Building 21140, Temperature Test Facility

ECO #	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
1	234	0	0	4,077	100	13.6	1.1
2	7	35	0	281	0	7.4	2.0

Electric energy unit price: \$0.221/kWh.

Electric demand unit price: \$19.50/kW.

5.2.5 Conclusion

The baseline energy consumption of P21140 is as follows:

Electrical: 1,565 MBtu/yr

Natural gas: 0

The annual specific energy consumption is 66,250 Btu/SF.

Both replacement of existing standard fluorescent lamps and ballasts with low wattage equipment and the installation of destratifying fans qualify for implementation.

5.3 BUILDING P21695, Special Weapons Assembly Building (SWAB)

5.3.1 Description of Existing Conditions

The building consists of four high bay areas with an adjoining office wing. The high bays are currently used for the preparation of missile launchers for test firing. The high bay lighting is explosion-proof incandescent, and the office lighting is standard fluorescent. The entire building is served by a single air handler with a chilled water coil and a steam heating coil. Steam is provided by a gas-fired boiler. Each high bay is equipped with a steam reheat coil. An air-cooled packaged chiller serves the air handler. There is no dry bulb economizer on the AHU.

Evaporative cooling is not used in the building, and is not a potential ECO, as the relative humidity in the high bay areas must remain below 50%.

Building survey notes are included in Volume II, Building Survey Forms.

5.3.2 Applicable ECOs

The following ECOs have potential application to Building 21695:

ECO #1: Reduced wattage fluorescent lighting in the office area (improved lighting).

ECO #2: Replace office windows with double paned, clear glass windows (windows).

ECO #3: Setback, setup thermostats (thermostats).

ECO #4: Dry bulb economizer on the AHU.

5.3.3 Method of Analysis

The TRACE 600 program was used to simulate the building baseline and ECO configurations. The results are shown in Table 5-3. Backup data is included in Appendix D, Tab 16, Volume I Book 2.

5.3.4 Results

The energy performance of each ECO is shown in Table 5-3 below. The economics of each ECO is shown in Table 5-4.

**TABLE 5-3
ANNUAL ENERGY USE DATA
Building 21695, SWAB**

Building P21695				Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
Baseline	252,112	81.3	869.6	-	-	-
ECO #1: Improved lighting	246,877	79.2	881.1	5,235	2.1	(11.5)
ECO #2: Windows	251,051	81.1	866.8	1061	0.17	2.8
ECO #3: Thermostats	215,642	81.3	476.7	36,470	0	392.9
ECO #4: Economizer	251,934	81.3	869.6	178	0	0

**TABLE 5-4
ECONOMIC SUMMARY
Building 21695, SWAB**

ECO #	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
1	116	488	(25)	4,259	0	8.2	1.8
2	23	0	6	5,107	0	83	0.2
3	806	0	869	136	0	0.1	128
4	5	0	0	997	0	242	0.04

Electric energy unit price: \$0.0221/kWh

Electric demand unit price: \$19.50/kW

Natural gas unit price: \$2.2124/MBtu

The baseline source energy consumption of P21695 is as follows:

Electrical: 860.5 MBtu/yr

Gas: 869.6 MBtu/yr

The annual area specific energy consumption is 99,147 Btu/SF.

5.3.5 Conclusions

Improved lighting and night setback thermostat are both cost effective, and relatively low cost to implement. Double pane windows and economizer controls on the air handler are not cost effective.

5.4 BUILDING 24072, HELICOPTER DRONE MAINTENANCE FACILITY (LAUNCH COMPLEX 38)

5.4.1 Description of Existing Conditions

Building 24072 was constructed around 1956 as a radar transmitter building in support of the Nike Zeus program. It is characterized by heavy concrete construction, extensive air handling equipment, high capacity electrical transformers, and extensive fluorescent lighting. Cooling coils used tower condenser water from Building 24066, which had no water treatment facilities. Consequently, many of the coils are disconnected and completely unserviceable. The building stood idle from approximately 1961 to 1965, and today serves as a maintenance facility for helicopter drones. Only a small portion of the building is in use. The main floor

high bay area is the maintenance function area. The adjacent office is also used. A portion of the basement is used for storage, while the rest of the areas are unused.

One air handler is in service and is served by steam from the boiler plant in Building 24066, and by chilled water from an air-cooled chiller. The office area is served by the air handler and by a reversible heat pump that exhausts to the maintenance bay.

The main electric transformer provides 480 V service to the building, but voltage measures at 530 V.

All fluorescent lights in the building are controlled from a single electric panel. Except for the office area, many of the 4-foot fluorescent fixtures are either burned out or nearly so. The lights are never turned off because up to three days are required for many of the lamps to relight when turned on.

The use of helicopter drones at the WSMR has decreased in recent years, and both the maintenance mission and the staff is quite small. The building is not well suited to house the helicopter drone maintenance function.

Survey notes are included in Volume II, Building Survey Forms.

5.4.2 Applicable ECOs

ECOs identified to configure the building for the existing tenant are:

ECO #1: Disconnect existing fluorescent lighting fixtures that serve unused areas. Retain safety lighting for these areas. Replace remaining fluorescent lighting with low wattage lamps and ballasts (improve lighting).

ECO #2: Install setback, setup thermostat with time clock to reduce runtime of the air handler, chiller compressor, and chilled water pump (AHU controls).

ECO #3: Install a dry bulb economizer on AHU-1.

5.4.3 Method of Analysis

The building baseline and ECO configurations were modeled on the TRACE 600 program. Backup data is included in Appendix D, Tab 17.

The synergistic effects of the ECO package were determined by first simulating the package as a whole, then backing out each ECO individually by replacing it with the system configuration from the baseline.

5.4.4 Results

ECO energy performance and economic results are shown in Tables 5-5 and 5-6.

TABLE 5-5
ANNUAL ENERGY USE DATA
Building 24072, Helicopter Drone Maintenance Facility

ECO				Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Propane Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Propane (MBtu)			
Baseline	452,691	61.9	659.0	-	-	-
ECO #1: Improve lighting	244,345	44.2	993.3	208,346	17.7	(334.3)
ECO #2: Setback thermostat	397,046	57.9	489.7	55,645	4.0	169.3
ECO #3: Economizer	449,695	61.8	659.0	2,996	0.2	0

TABLE 5-6
ECONOMIC SUMMARY
Building 24072, Helicopter Drone Maintenance Facility

ECO #	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Propane Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
1	4,604	990	(2,243)	11,338	0	1.9	6.9
2	1,230	936	1,136	2,016	0	0.7	16.6
3	66	39	0	2,047	0	21.7	0.5

Electric energy unit price: \$0.0221/kWh

Electric demand unit price: \$19.50/kW

Propane unit price: \$6.71/MBtu

The annual baseline electrical consumption is 1,544 MBtu, and the propane consumption is 659 MBtu. The total annual baseline source energy consumption is 2,204 MBtu, or 61,989 Btu/SF.

5.4.5 Conclusions

ECOs #1 and #2 are cost effective, and will significantly reduce the building energy consumption. The lighting ECO will improve working conditions for the tenant, and the use of a setback thermostat should not adversely impact occupant comfort.

The results of the building modified configuration which includes both qualifying ECOs are presented in Tables 5-7 and 5-8. Both ECOs are still cost effective in the package, and the modified configuration is recommended.

**TABLE 5-7
ANNUAL ENERGY USE DATA
BUILDING 24072: ECO PACKAGE**

ECO	Energy Use			Energy Savings		
	Elec (kWh)	Elec (kW)	Propane (MBtu)	Elec. (kWh)	Elec. (kW)	Propane (MBtu)
Modified Configuration	199,524	43.5	637.2	253,167	18.4	21.8
ECO #1 Improve Lighting	397,046	61.8	489.7	197,522	18.3	(147.5)
ECO #2 Setback Thermostat	237,250	40.6	993.3	37,726	(2.9)	356.1

**TABLE 5-8
ECONOMIC SUMMARY
BUILDING 24072: ECO PACKAGE**

ECO #	Elec. Energy (\$/yr)	Elec. Demand (\$/yr)	Propane Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
Modified Configuration	5,595	4,310	146	13,355	0	1.5	7.3
ECO #1	4,365	4,290	(990)	11,338	0	1.7	8.7
ECO #2	834	(683)	2,389	2,016	0	0.9	13.9

The modified baseline configuration annual electrical energy consumption is 681.0 MBtu, and the propane consumption is 637.2. The total annual modified baseline source energy consumption is 1,315.2 MBtu, or 36,991 Btu/SF, which is 40% less than the existing baseline energy consumption.

SECTION 6.0

ENERGY STUDIES FOR LAUNCH COMPLEX 38

6.1 GENERAL

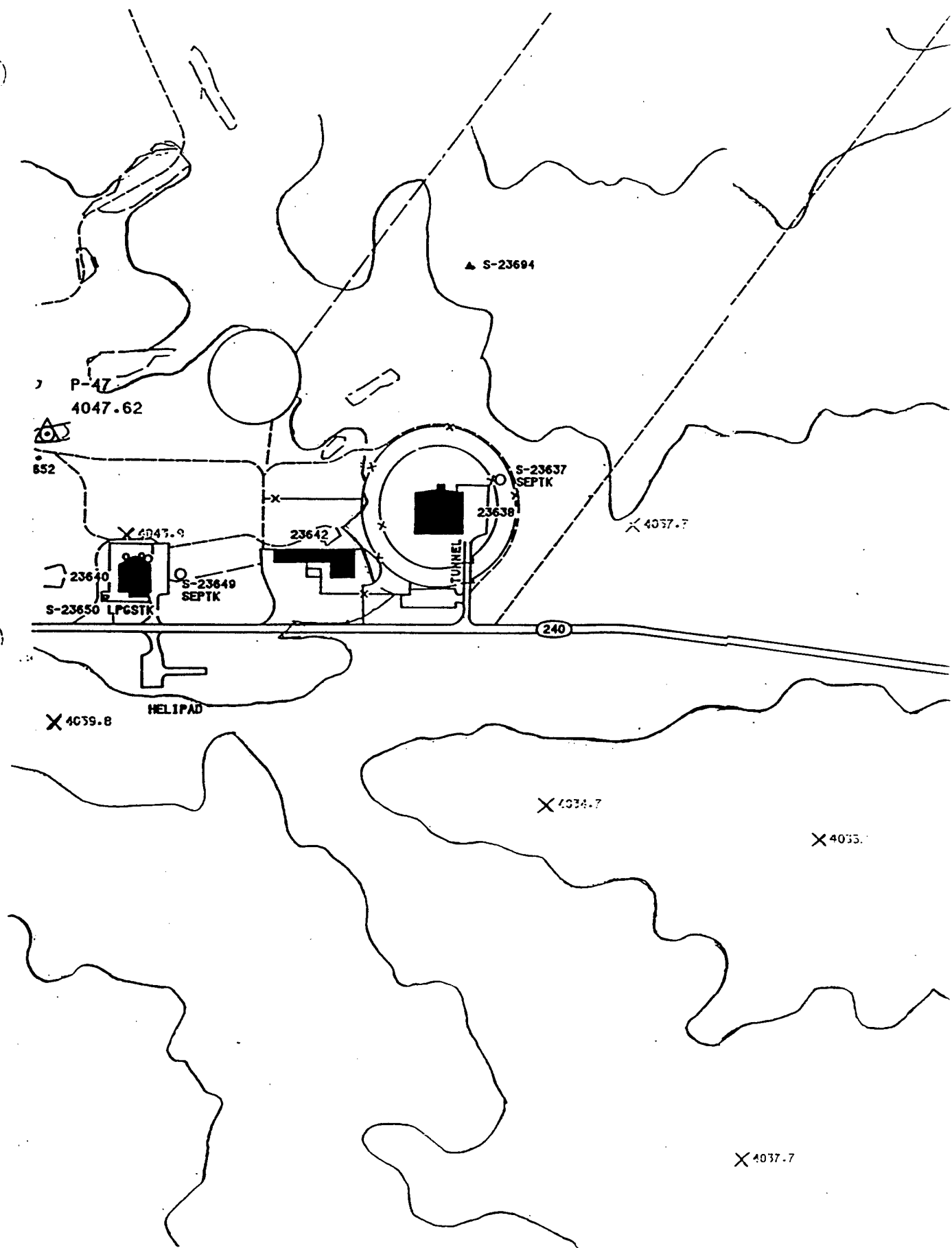
This section addresses paragraph 4.3.2 in Annex B of the Scope of Work, Appendix A. The requirement is to determine the technical and economic feasibility of refurbishing the chilled water side of the central plant located in Building 24066 to serve P24072, P23638, P23640, and P23642. The site map for the five buildings to be studied is presented in Figure 6-1.

The four buildings are operational, but the functional uses have changed so that the air-conditioning loads are greatly reduced from the original designs.

Central plant P24066 contains steam boilers and two 550 ton centrifugal chillers. The boilers are active, but the chilled water side was shut down sometime around 1960.

Central plant P24066 and the four load buildings were surveyed to determine the condition and use of chilled water equipment in each of the buildings. The air-conditioning load of each building was modeled on the TRACE 600 program.

All backup calculations and computer simulation reports are included in Appendix D, Tab 18 in Volume I Book 2.



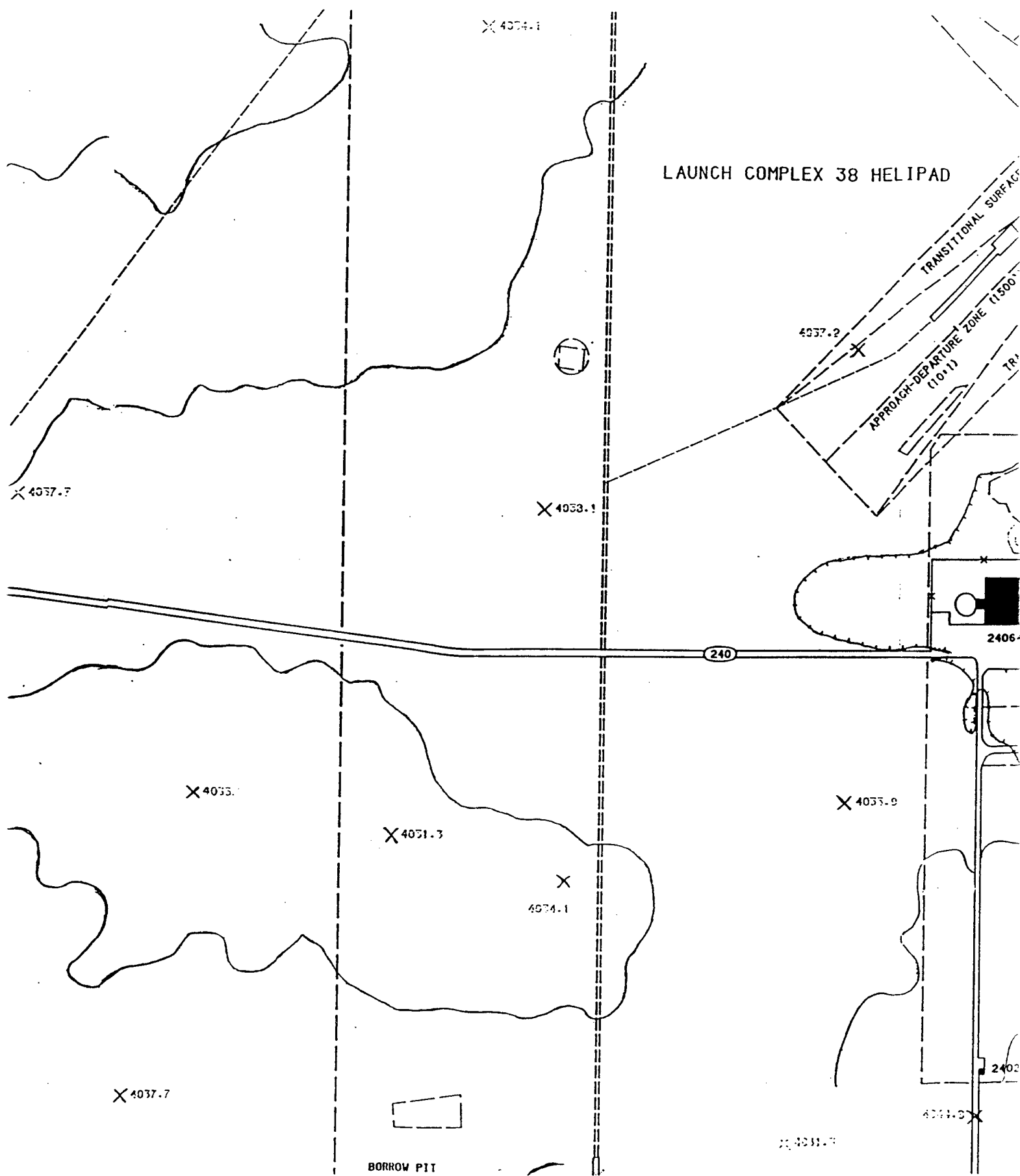


FIGURE 6
6-2

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6-2

6.2 HISTORICAL BACKGROUND

Launch Complex 38 was constructed in 1956 as a Nike Zeus missile test complex. It consisted of six buildings as shown in Figure 6-1 on page 6-2. Each building was constructed as a special facility with heavy concrete and steel construction and shielding. Air-conditioning loads were heavy, and central plant P24066 served P24068 and P24064 with chilled water. Buildings P24072, P23638, P23640 and P23642 were all constructed with their own chilled water equipment. However, the cooling tower at P24066 provided tower water to P24072 to cool large radar transmitters, and the tower provided condenser water for the two chillers in P24066.

The Nike Zeus program was terminated in approximately 1960, and the special equipment was removed from the various buildings. The buildings sat vacant for several years, and were subsequently put to other uses. The peak air-conditioning loads at the present are a small fraction of the original loads, and the existing chilled water equipment (and air handlers) are oversized.

6.3 DESCRIPTION OF EXISTING CONDITIONS

At the time of the survey of the various facilities at the WSMR, information on what was done in 1960 to shut down the chilled water side of P24066 was not available. It was not possible to determine the interior condition of the two centrifugal chillers in P24066, but it was possible to determine the condition of the cooling tower and of the tower water system that served P24072.

The chilled water equipment inside P24066 was inspected externally. The piping insulation, pumps, and chillers all appear to be in excellent condition. In all probability the interior of the entire condenser water system (pipes, pumps and chiller condensers) are badly scaled and corroded. This conclusion is based on the observed condition of the tower water system in P24072. The chillers are much too oversized for the current chilled water load on the four buildings.

The cooling tower is badly deteriorated. Extensive dry rot of the wooden structure and evaporative media is visibly evident. Photographs 1 through 6 starting on page 6-5 indicate the state of deterioration. Photographs 9 through 12 starting on page 6-11 depict the condition of the tower cooling water piping network. Apparently a good water treatment program for the tower water system was never implemented. All mechanical tower equipment—pumps, fans, variable pitch blade actuators, fan motors—are badly corroded. If the chillers were to be placed into operation, the tower is grossly oversized for the consolidated chilled water load of the four buildings to be served.

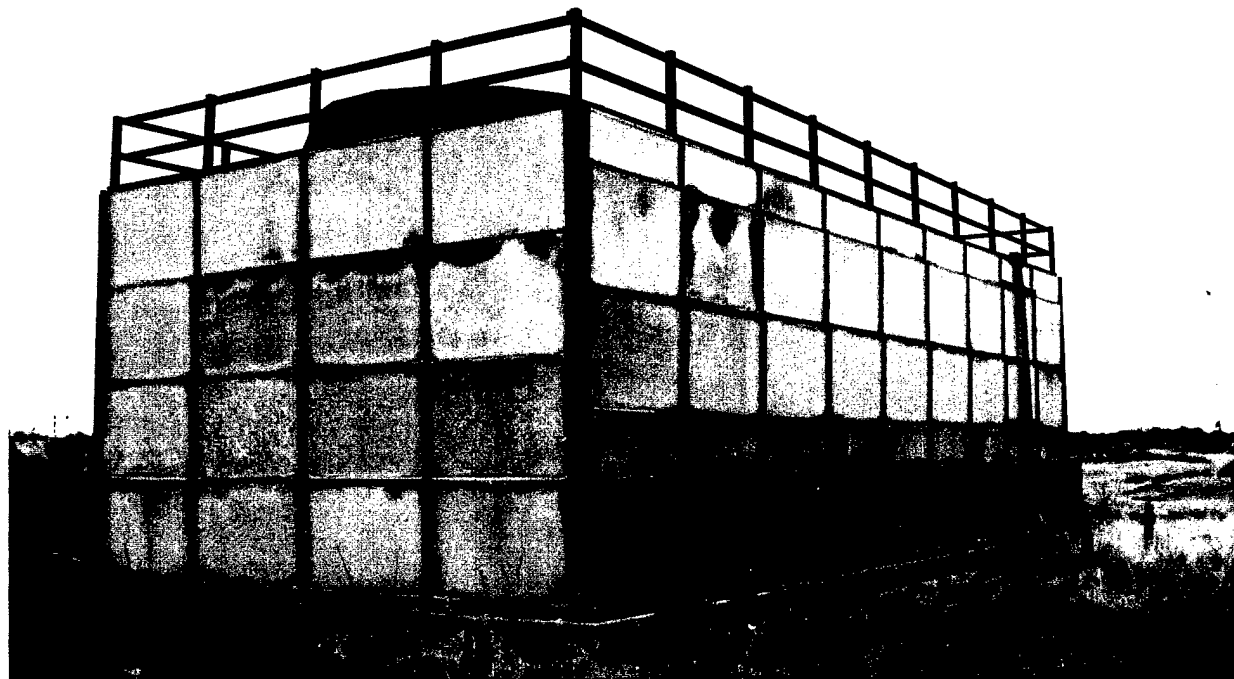
The tower is deteriorated beyond repair and would have to be replaced with a unit sized for the existing load.

The 300-ton centrifugal chiller in P23638 is oversized for the current air-conditioning load, which is a peak load of only 62 tons. From late fall to spring, the building peak load gets as low as 35 tons. During these periods the 300-ton centrifugal frequently cycles and sometimes

trips off line. The wooden cooling tower is badly deteriorated, and is well beyond its service life. A work order has been written to replace the chiller and cooling tower with two 50 ton air-cooled chillers.

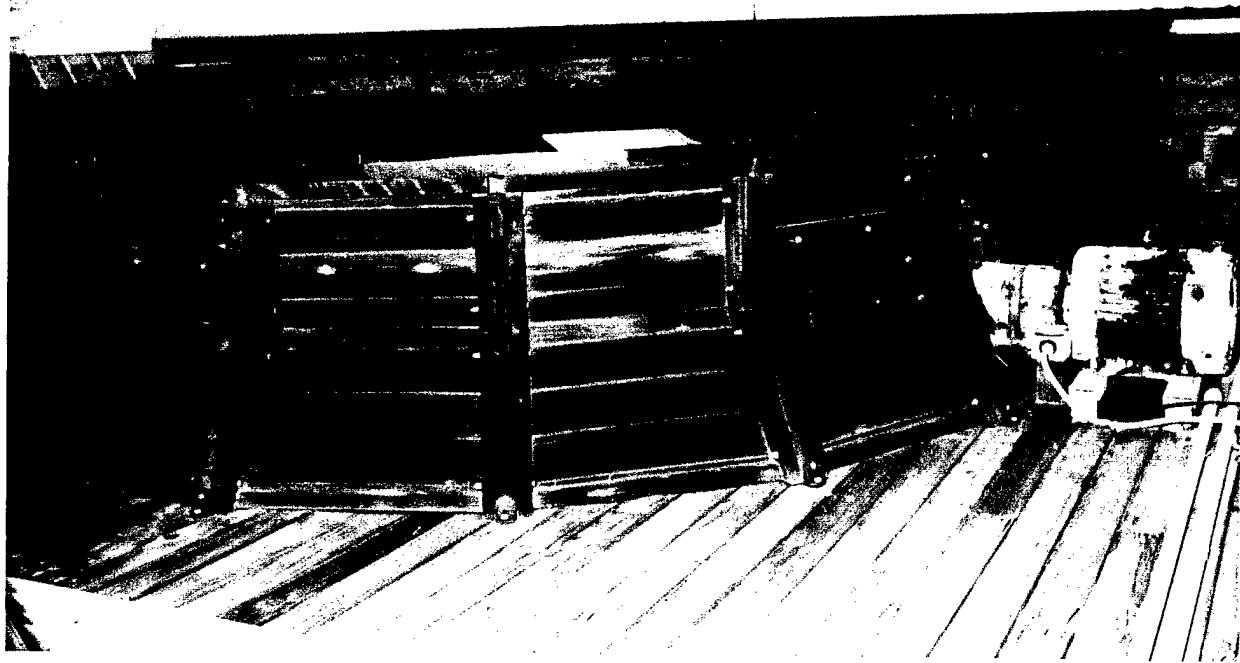
Building P23640 is served by a 75-ton reciprocating, water-cooled chiller, which is oversized for the 29 ton peak load. The equipment is serviceable and well maintained. Several months after the field survey of the building under this contract two new 50 ton air-cooled chillers were installed at P23640.

Building P23642 is served by two centrifugal chillers, much oversized for the current load. The original cooling tower has been replaced by a liquid cooler.



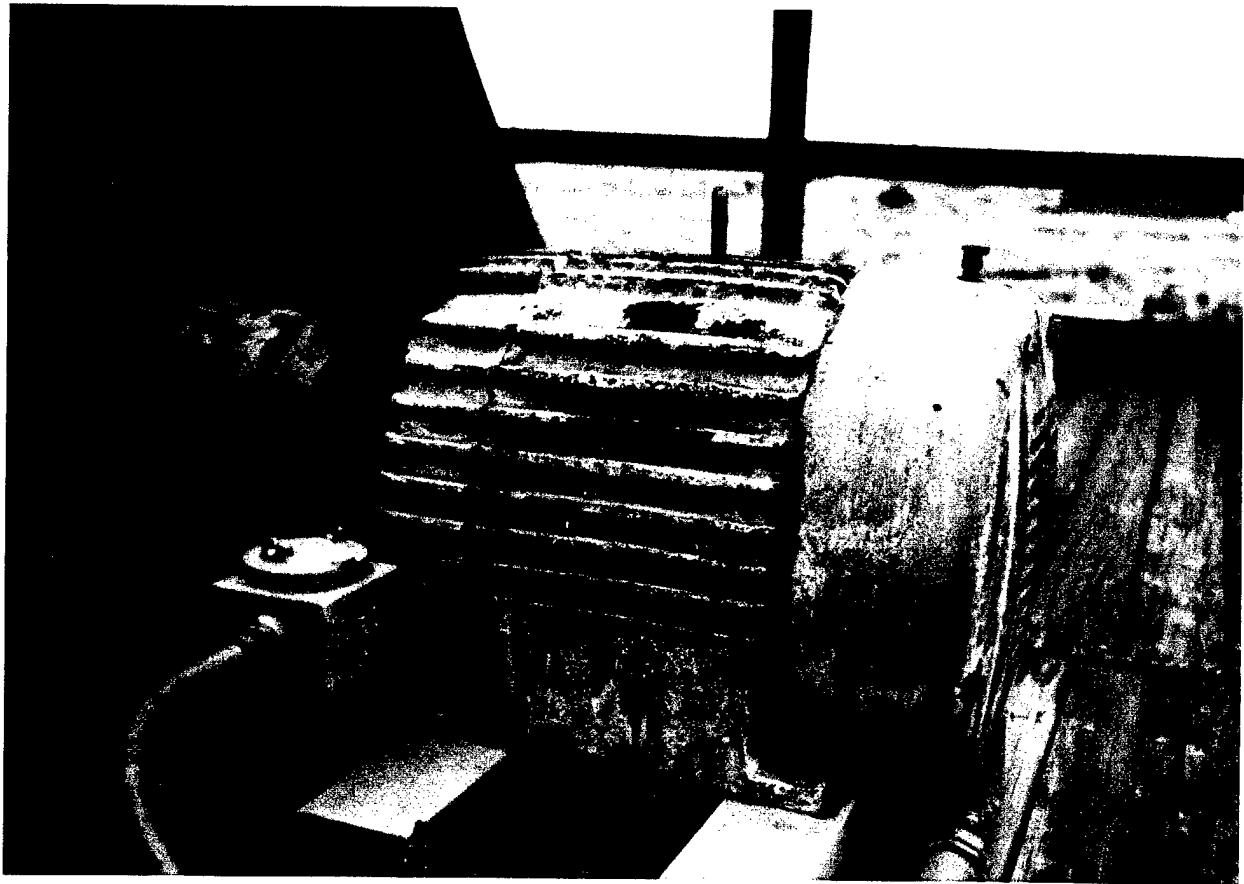
PHOTOGRAPH 6-1. Cooling Tower at P24066

Photograph 6-1 shows the two cell counterflow wooden cooling tower that serves two centrifugal chillers located in P24066. The view is to the southeast.



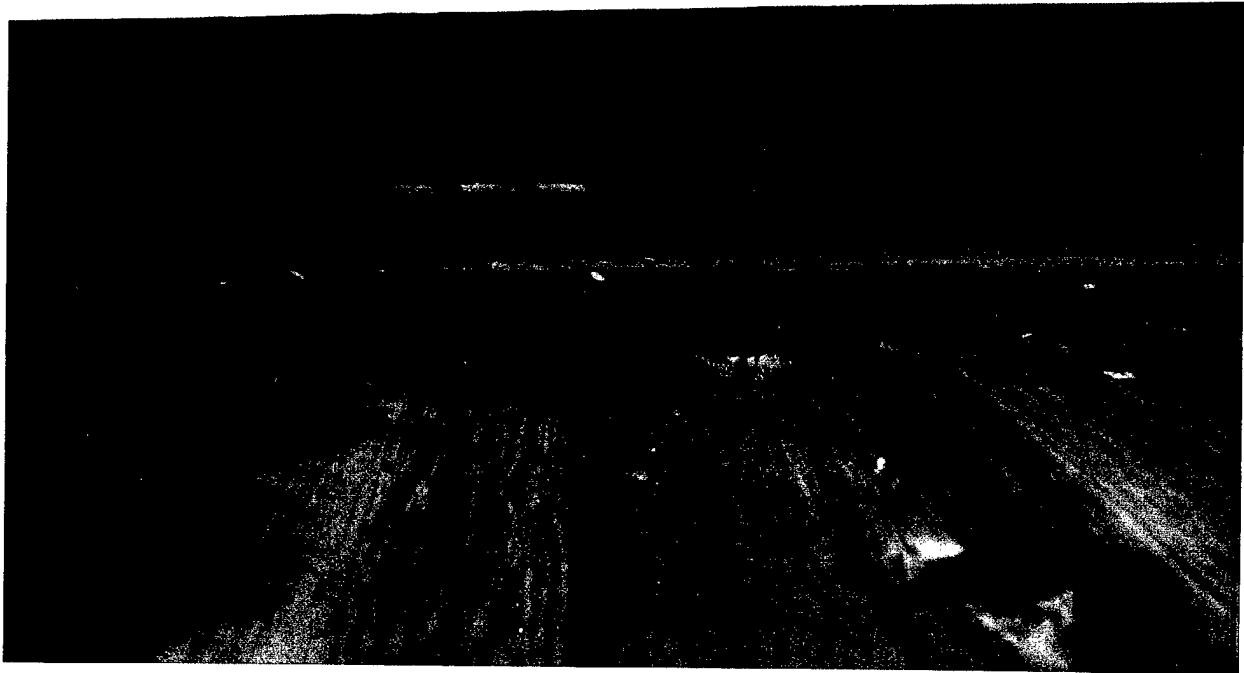
PHOTOGRAPH 6-2. Wooden Diffusers on Top of Cooling Tower

Photograph 6-2 shows the two wooden tower diffusers with the fan motors mounted on the roof deck. The diffuser structure has deteriorated to the point that one may grasp the ring of the diffuser and move it 6 to 8 inches back and forth.



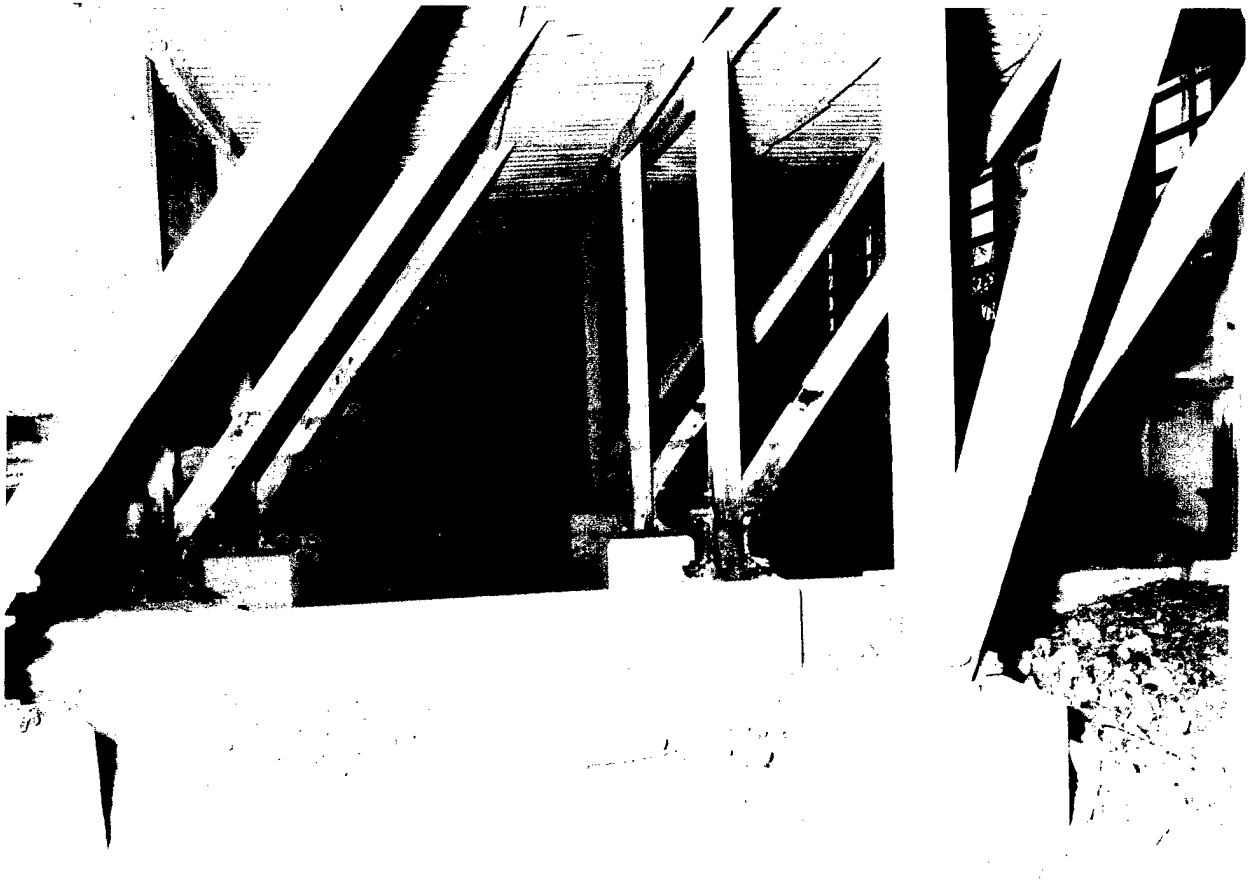
PHOTOGRAPH 6-3. Cooling Tower Fan Drive Motor

Photograph 6-3 is of one of the two fan drive motors bolted to the roof deck of the cooling tower. The deck of the tower roof is badly deteriorated and no longer provides a solid base for the fan motors.



PHOTOGRAPH 6-4. Cooling Tower Roof Deck

In Photograph 6-4 the nails protruding from the roof deck illustrate the advanced state of dry rot that prevails in the tower structure.



PHOTOGRAPH 6-5. Supporting Wooden Beams of the Cooling Tower

Photograph 6-5 shows that the substructure of the cooling tower is intact, but also shows evidence of dry rot and advanced corrosion of metal brackets that secure supporting beams to concrete footers.



PHOTOGRAPH 6-6. Metal Bracket in the Cooling Tower Foundation

Photograph 6-6 is a closeup of a badly corroded metal bracket which illustrates the advanced state of corrosion that is prevalent of all metal components in the cooling tower structure.



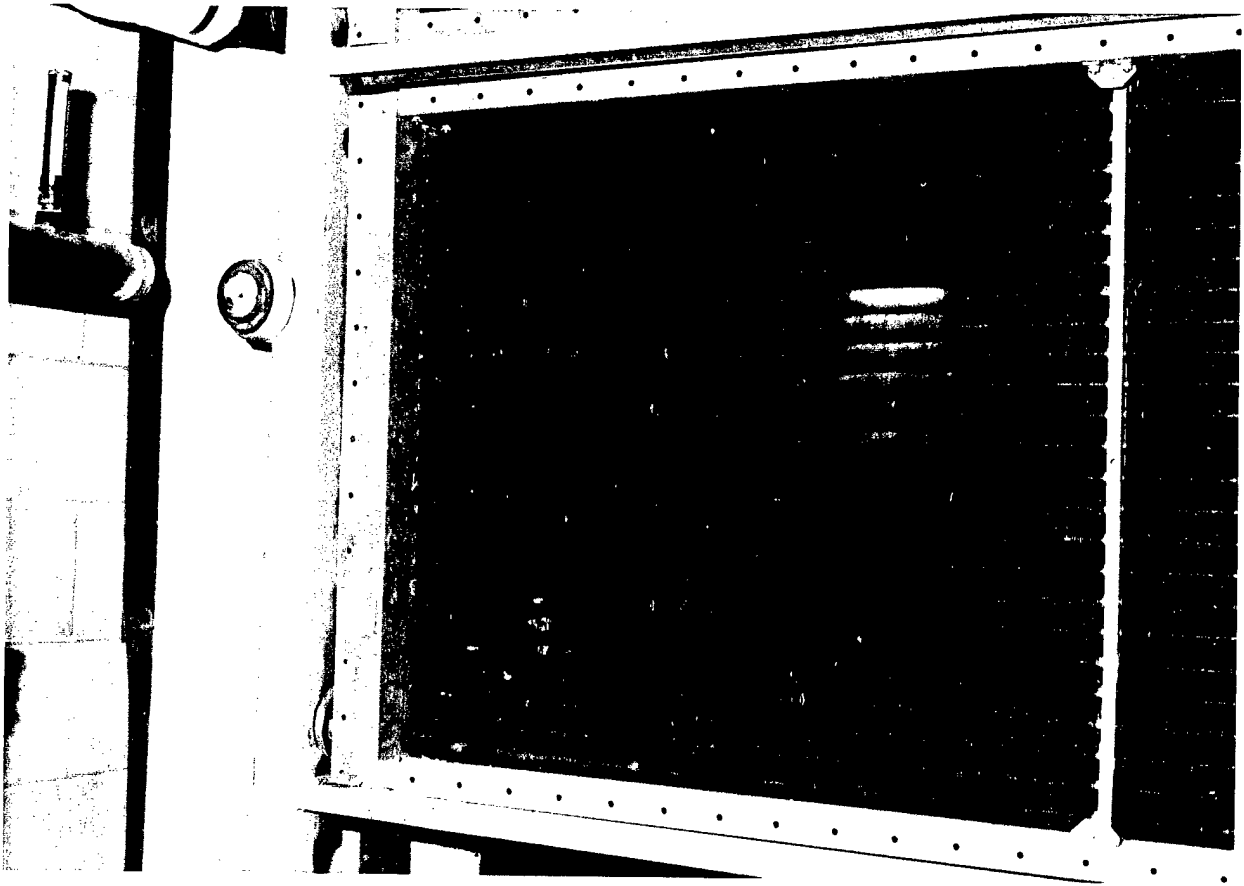
PHOTOGRAPH 6-7. Entrance to a Pipe Tunnel that Connects to Building P24072

Insulated steam and condensate pipes and uninsulated tower water pipes that serve Building P24072 are shown in Photograph 6-7. The steam and condensate pipes are active. The tower water pipes have been inactive since approximately 1960.



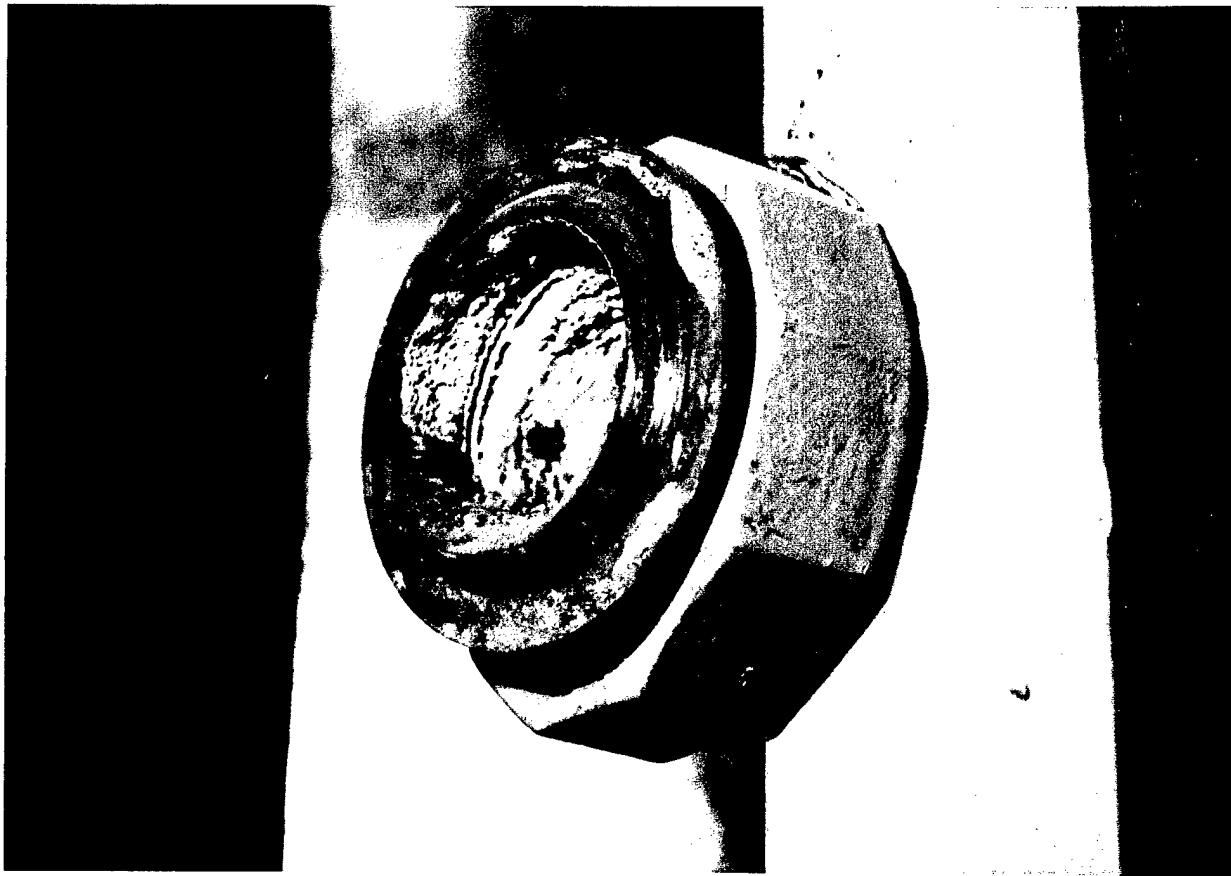
PHOTOGRAPH 6-8. Building P24072 with the Piping Tunnel on the Left

Photograph 6-8 shows the west elevation view of Building P24072. The entrance to the piping tunnel is just out of view on the left. The building is a heavy concrete structure, clad in a metal shield. The building used to contain radar transmitters that were cooled with tower water.



PHOTOGRAPH 6-9. A Tower Water Coil in Building P24072

Photograph 6-9 shows one of the abandoned tower water cooling coils in P24072. The supply pipe on the left has been cut and the condition of the pipe interior surface is exposed to view.



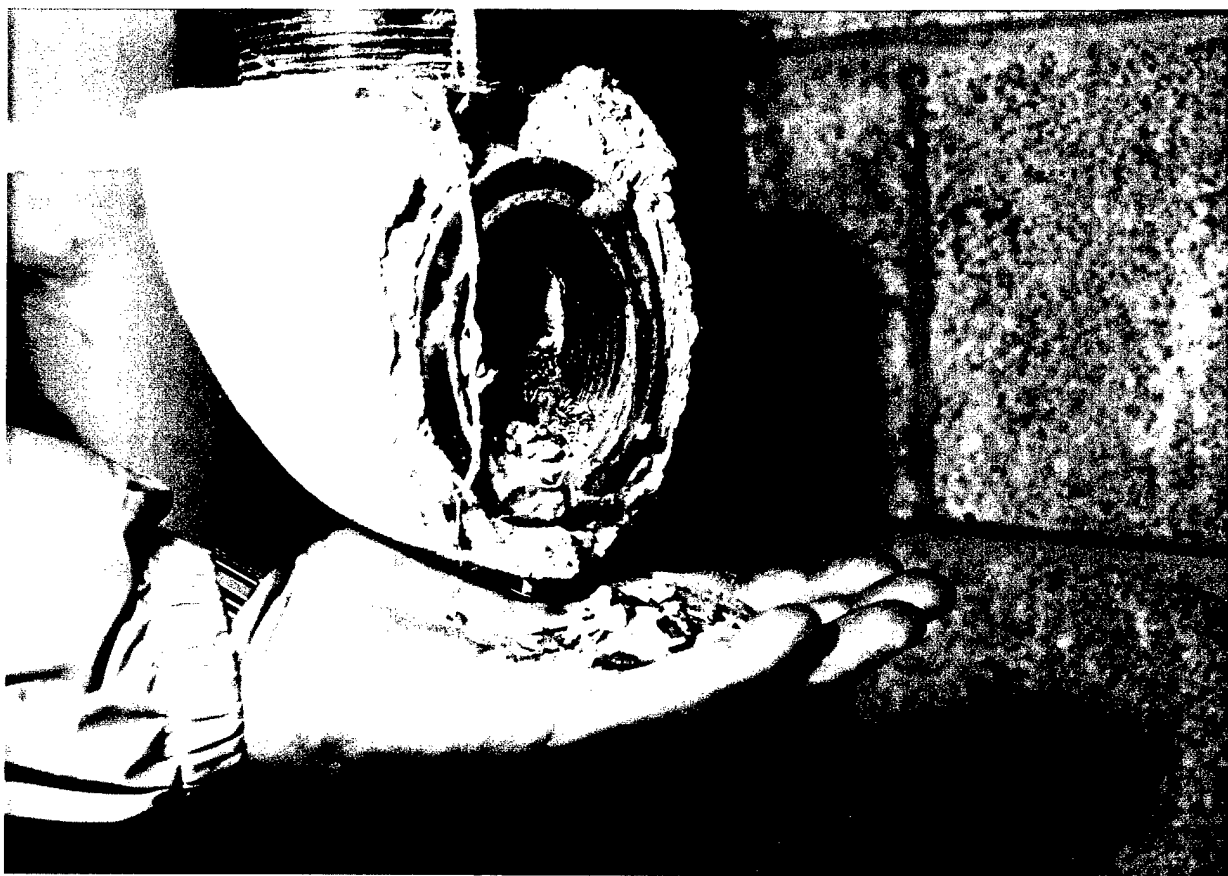
PHOTOGRAPH 6-10. Close-up View of a Tower Water Supply Pipe

The pipe connection to the cooling coil in Photograph 6-9 is shown above.



PHOTOGRAPH 6-11. Tower Water System Piping in P24072

The extent of internal scaling and corrosion of the tower water piping is shown in Photograph 6-11.



PHOTOGRAPH 6-12. Tower Water Cooling Piping in P24072

Photograph 6-12 shows another example of the deterioration of the tower water piping.

TABLE 6-1
EQUIPMENT AND PERFORMANCE DATA (BASELINE)

Bldg.	No. of Chillers	Chiller Type	Total Capacity (Tons)	Peak Load (Tons)
P23638	1	Centrifugal	300	62
P23640	1	Reciprocal	75	29
P23642	2	Centrifugal	150	25
P24072	1	Air-cooled reciprocal	75	21
Total Baseline Data			600	137

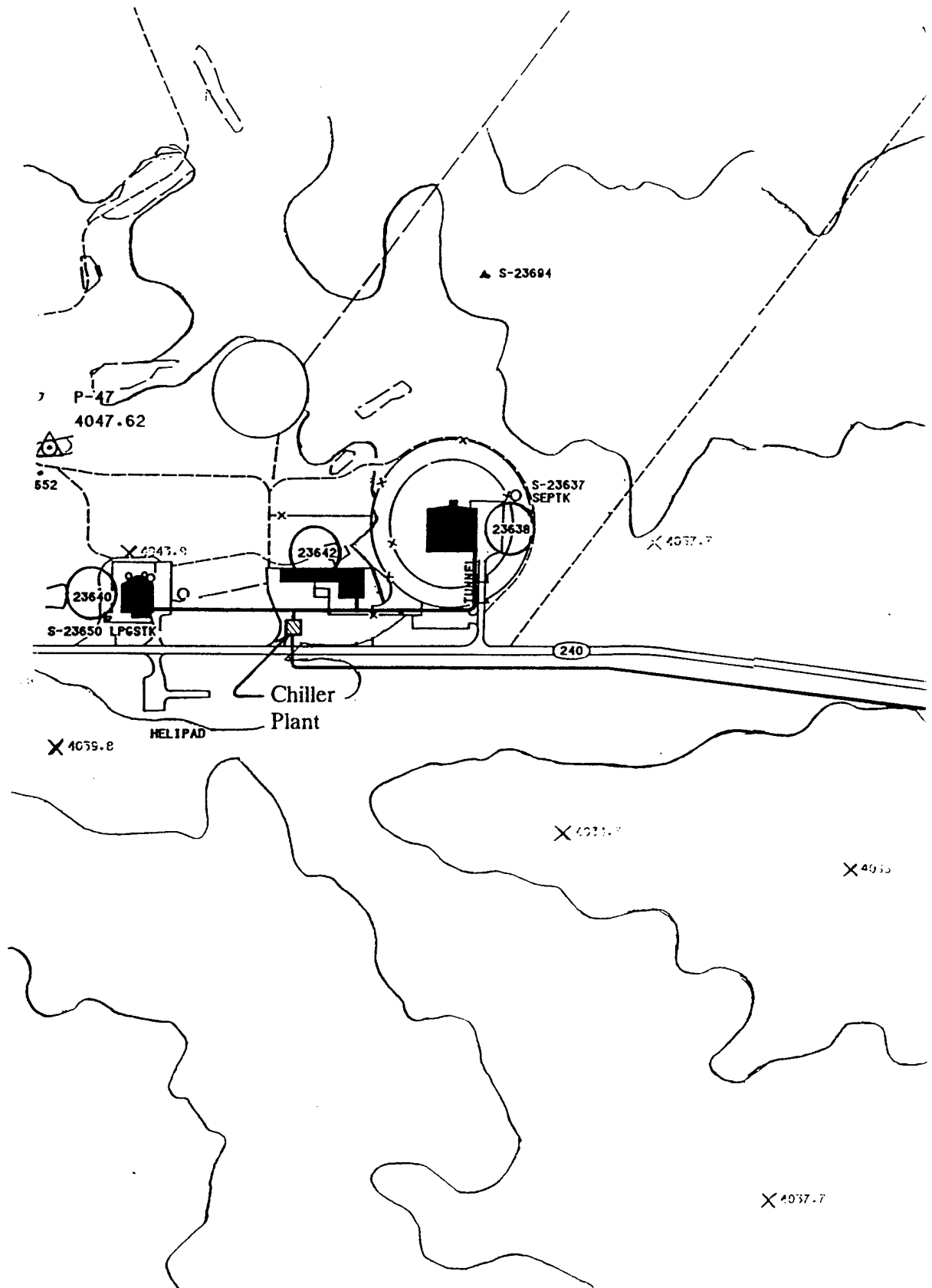
6.4 CONCEPT DESIGN ALTERNATIVES

Because the existing chilled water plant in P24066 is beyond refurbishment, and the air-conditioning equipment in the four buildings to be served is oversized, four concept design alternatives to correct chilled water systems deficiencies were identified.

Alternatives 1A and 1B consider the construction of a new central chilled water plant near Building P23638 to serve all four load buildings (see Figure 6-2 on page 6-18). Chilled water supply and return pipes must extend about one mile to Building P24072.

Alternatives 2A and 2B consider the construction of a new chilled water plant near Building P23642 to serve P23640, P23638 and P23642. In these alternatives, Building P24072 is served by its existing air-cooled cold generator (see Figure 6-3 on page 6-19).

Table 6-2 on page 6-20 presents equipment size, type, performance data, cost data and a summary of the economic analysis for each alternative.



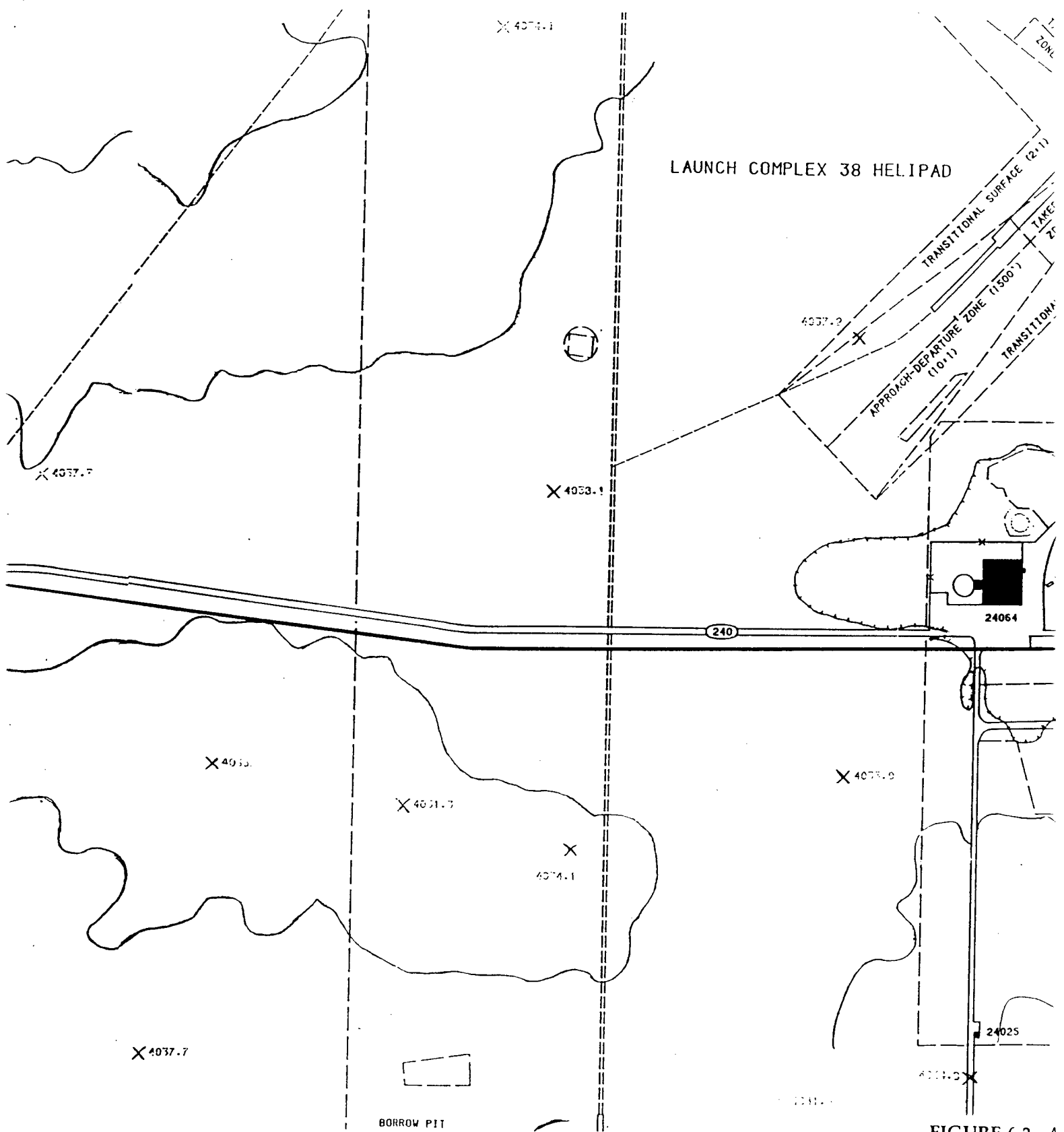


FIGURE 6-2. A
P

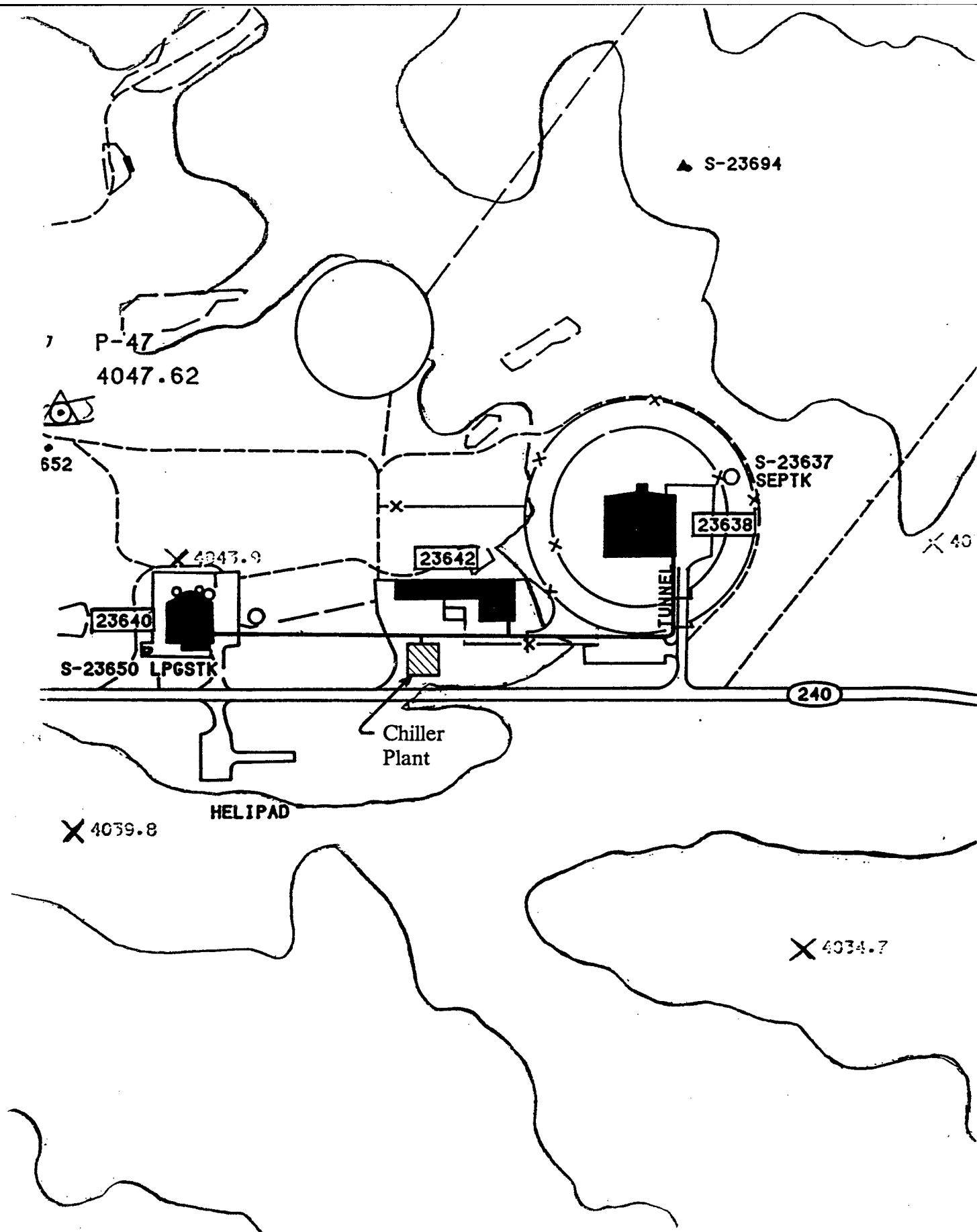


FIGURE 6-3. ALTERNATIVES 2A AND 2B SITE PLAN AND LAYOUT

TABLE 6-2
LAUNCH COMPLEX 38 CHILLER PLANT STUDY SUMMARY

	No. of Chillers	Chiller Type	Plant Capacity (Tons)	Annual kWh	Average Monthly Peak kW
Baseline			600	2,432,865	125.2
Alt. 1A	1	Air-cooled chiller	200	1,113,018	124.5
Alt. 1B	1	Water-cooled chiller	150	1,058,413	68.6
Alt. 2A	1	Air-cooled chiller	140	1,268,502	126.5
Alt. 2B	1	Water-cooled chiller	130	1,213,571	67.6

	Electric Energy Savings (\$/yr)	Electric Demand Savings (\$/yr)	Probable Construc. Cost (\$)	Maint. Cost Savings (\$/yr)	Simple Payback (yrs)	SIR
Alt. 1A	29,190	150	371,979	(6,309)	11.5	1.6
Alt. 1B	30,398	13,242	703,072	(7,078)	15.8	1.09
Alt. 2A	25,751	(308)	325,091	1,855	9.4	1.9
Alt. 2B	26,966	13,475	367,262	778	7.8	2.2

6.5 CONCLUSIONS AND RECOMMENDATIONS

Each of the four alternatives are economically feasible. Alt. #1B and Alt. #2B are water-cooled plants, and are more cost effective than the air-cooled plants in Alt. #1A and Alt. #2A. In Alt. #2B the cost of laying a mile of chilled water pipe to serve P24072 is avoided, and Alt. #2B is the most cost effective.

During the field survey in November, 1991, it was learned that new air-cooled chillers had been requested for P23638, and possibly for P23640.

The interim report presentation and review meeting was held at the WSMR on May 28 and May 29, 1992. At that time the attendees visited LC38 to see the condition of the buildings. It was noted that two new Trane air-cooled chillers had been installed at P23640. These are 50 ton units, without precoolers. Also, in discussions with the tenant at P23642, it was determined that necessary building air-conditioning modifications have a high priority, and cannot wait on long term funding programs such as the ECIP. As a result, it was decided to abandon the consolidated chiller plant concept for LC38 (see Confirmation Notice 009 in Appendix A). None of the 4 alternatives are recommended for implementation because of the changes in operating conditions in LC38.

SECTION 7.0

CONTRACTOR-IDENTIFIED ECOs

7.1 GENERAL

In the course of surveying Buildings P23640 and P23642 in Launch Complex 38 in support of the study to refurbish the chilled water side of P24066, several building ECOs were identified. Basically the HVAC systems are greatly oversized for the existing air-conditioning loads, and the energy consumption is greater than it needs to be. In the case of both of these buildings, major space conditioning discrepancies may be corrected at the same time that energy consumption is reduced. This section presents the analysis of ECOs for the two buildings. Backup data is found in Appendix D, Tab 19 in Volume I Book 2.

7.2 BUILDING P23640 (LAUNCH COMPLEX 38)

7.2.1 Description of Existing Conditions

Building P23640 houses a data reduction facility and a few technicians in support of a missile program. The building consists of a small computer room, a technician area, a large unused room with a raised floor, and an office area near the main entrance. A large mechanical equipment room houses two air handlers, a steam boiler, and a reciprocating chiller. A single cell, counterflow cooling tower serves the chiller¹.

The main air-handler (AHU-1) is equipped with a chilled water coil and a steam humidifier. It serves the entire building except for the entry area on the east side of the building and the mechanical room. The second air handler (AHU-2) also serves the same areas (overhead ducts with steam reheat coils). The mechanical room and the entry are heated with steam coil unit heaters and cooled by evaporative coolers.

AHU-2 has provision for a cooling coil, which has been removed. It is the only air handler with makeup air, and currently is only used in the winter for space heating.

The entire building is equipped with fluorescent lights. Most lamps and ballasts are of the standard type.

¹The water-cooled chiller was replaced by two 50 ton air-cooled chillers in the spring of 1992.

7.2.2 Applicable ECOs

A modified building configuration is identified that conserves energy and better configures the building systems to meet the tenant's needs. The modified configuration includes the following ECOs:

- Upgrade AHU-2 by installing a chilled water coil, repairing the make-up damper actuator, installing an economizer control.
- Replace the fan motor on AHU-1 to reduce the supply airflow rate to 1.5 cfm/SF.
- Optimize the supply air temperature setpoint on AHU-1 and AHU-2.
- Install a dry bulb economizer on AHU-2.
- Reset chilled water supply temperature to maintain 55°F return chilled water temperature (6°F reset).
- Replace standard fluorescent lamps and ballasts with low wattage lamps and ballasts.

7.2.3 Results

Energy performance and economic results are presented in Tables 7-1 and 7-2 below.

**TABLE 7-1
ANNUAL ENERGY USE DATA
Building P23640, Mission Support**

P23640	ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Propane Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Propane (MBtu)			
Baseline	689,253	112.5	409.8	-	-	-
Modified configuration	432,687	75.1	220.8	256,566	37.4	189

TABLE 7-2
ECONOMIC SUMMARY
Building P23640, Mission Support, Modified Configuration

Electric Energy (\$/yr)	Electric Demand (\$/yr)	Propane Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost (\$)	Simple Payback (yrs)	SIR
5,670	8,756	1,268	15,025	0	1.1	10.2

Unit electrical energy price: \$0.0221/kWh

Unit electrical demand price: \$19.50/kW

Unit propane energy price: \$6.71/MBtu

7.2.4 Conclusions

The modified configuration significantly reduces energy consumption and utility costs, and improves the building operation for the tenant by providing constant ventilation. The modified configuration should be implemented.

7.3 BUILDING P23642 (LAUNCH COMPLEX 38)

7.3.1 Description of Existing Conditions

The building consists of the original building and an office wing that was subsequently added. No drawings of the office wing were located, and all data was taken by field measurements. Survey notes are included in Volume II, Building Survey Forms.

The original building houses a large vault which is now used as office space for analysts, a large mechanical room, and several unused rooms specially designed for the original mission. The mechanical room equipment includes a water-cooled reciprocating chiller served by a fluid cooler, a large air handler with chilled water and steam coils (AHU-1), a boiler, and chilled water pumps. The vault originally contained process equipment that required large supply airflows, which the current use of the room does not. The airflow rates have not been reduced and consequently, vault occupants must turn off AHU-1 most of the time, and operate it only periodically to restore room comfort conditions. It is extremely difficult to work in the room with AHU-1 operating. The vault is also equipped with a steam fan coil unit for heating, but this unit is not in use. The reason for this was not determined.

An office wing was added to the building on the west end. The wing has two zones, served by two air handlers (AHU-2 and AHU-3) equipped with chilled water and steam preheat coils. Multi-stage duct-mounted electric resistance heaters serve the two zones, which have excessive supply air.

7.3.2 Applicable ECOs

ECOs identified to configure the building for the existing tenants are:

- Replace standard fluorescent lamps and ballasts with low wattage lamps and ballasts.
- Reduce supply cfm on all three AHUs.
- Install dry bulb economizers on AHUs-1, -2, and -3.
- Replace fan motors on all AHUs with high-efficiency, downsized motors.

7.3.3 Results

The baseline and modified configuration energy consumptions are shown in Table 7-3. Economic results of the proposed modified configuration are shown in Table 7-4 below.

TABLE 7-3
ANNUAL ENERGY USE DATA
Building P23642, Mission Support

P23642	ECO			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Propane Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Propane (MBtu)			
Baseline	341,507	88.9	74.4	-	-	-
Modified Configuration	287,506	66.8	87.2	54,001	22.1	(12.8)

TABLE 7-4
ECONOMIC SUMMARY
Building P23642, Mission Support, Modified Configuration

Electric Energy (\$/yr)	Electric Demand (\$/yr)	Propane Energy (\$/yr)	Construction Cost (\$)	Maintenance Cost (\$)	Simple Payback (yrs)	SIR
1,193	5,187	(90)	24,053	0	4.3	2.5

Unit electrical energy price: \$0.0221/kWh

Unit electrical demand price: \$19.50/kW

Unit propane energy price: \$6.71/MBtu

7.3.4 Conclusions

The modified configuration addresses the main discrepancies in the building lighting and conditioning systems and is cost effective.

7.4 RECOMMENDATIONS

The modified configurations for Buildings P23640 and P23642 should be implemented. The retrofit changes will improve building conditions for the tenants, save energy and reduce annual O&M costs.

SECTION 8.0

DEMAND LIMITING MEASURES

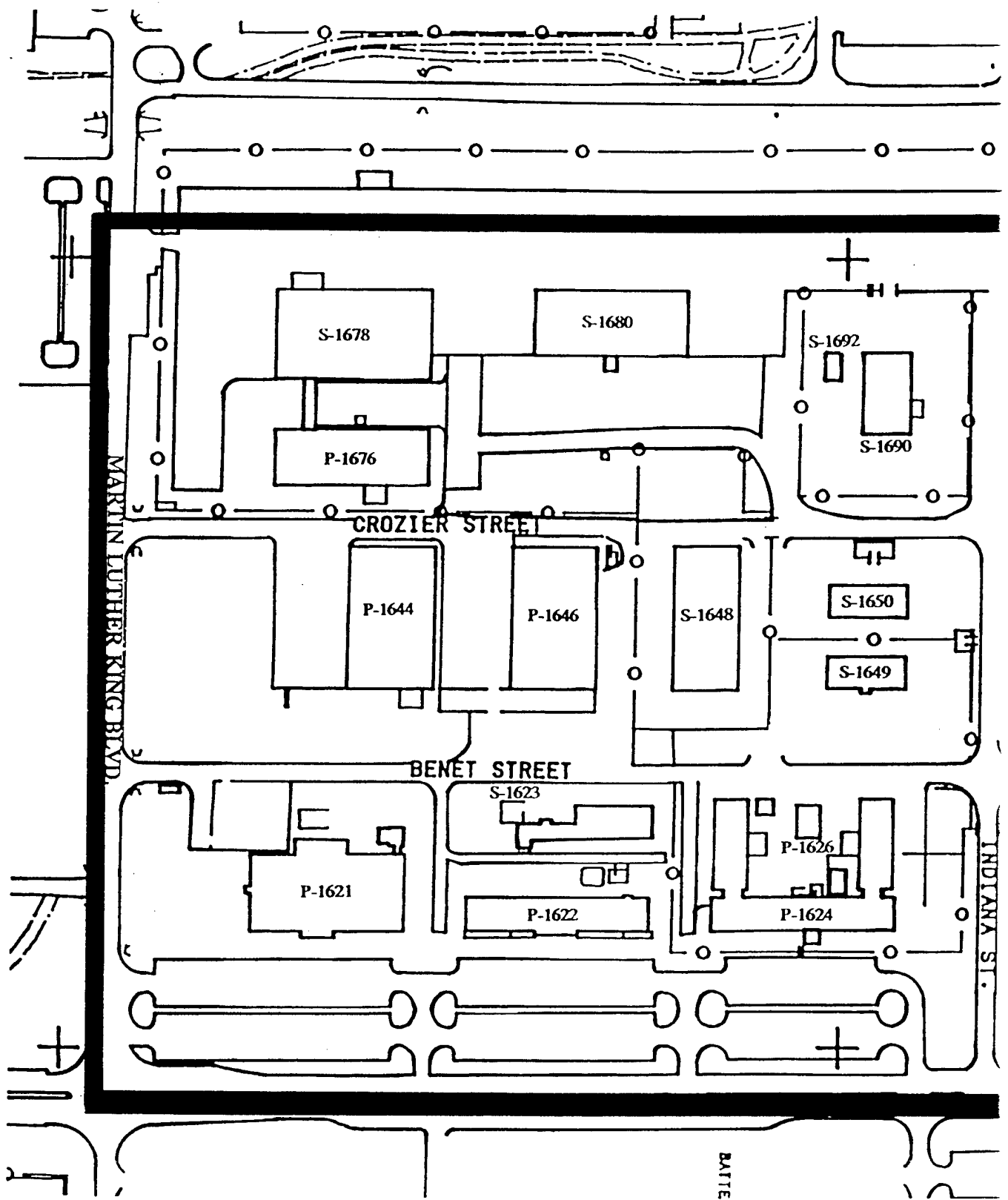
8.1 GENERAL

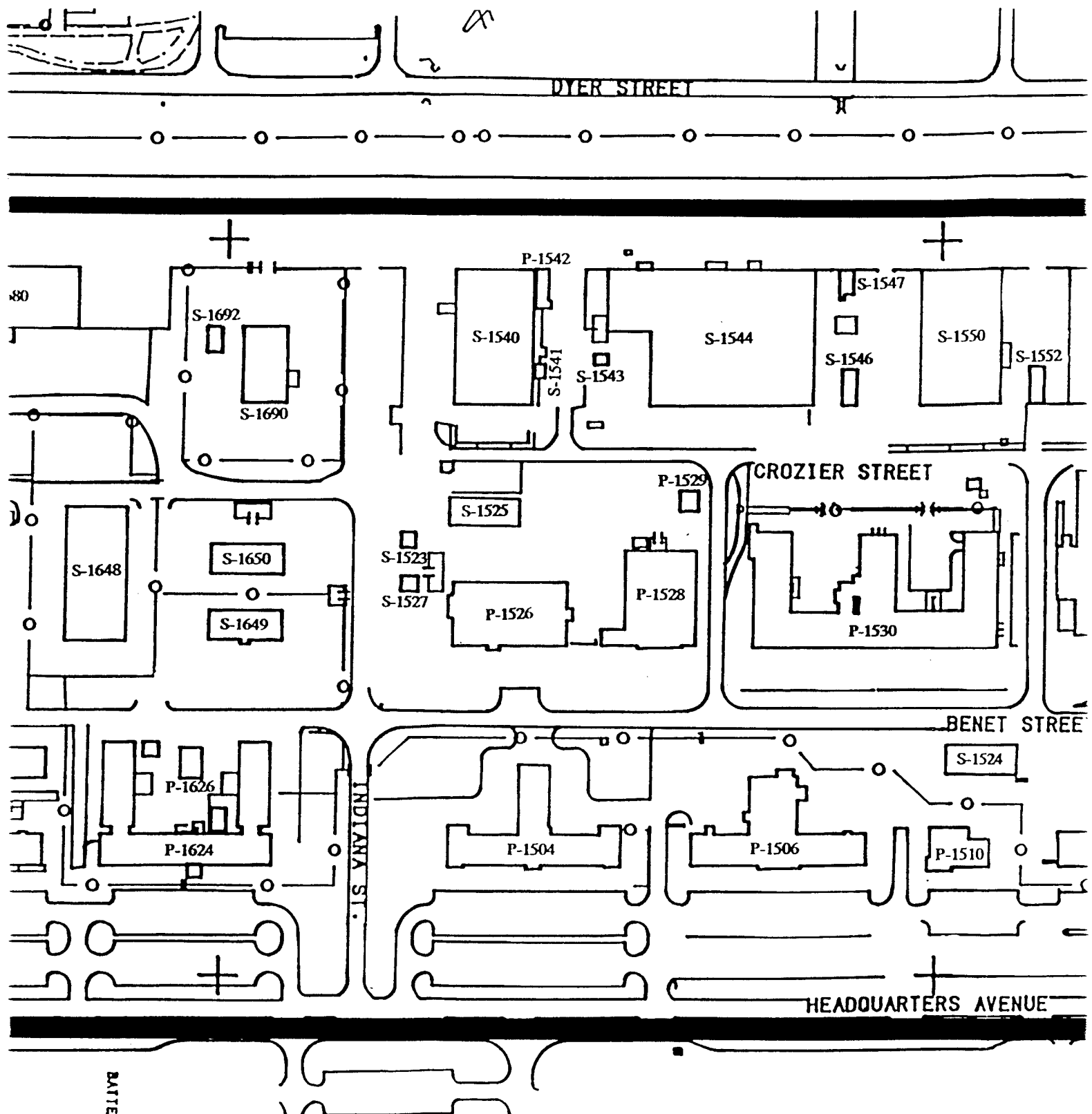
Paragraphs 4.2a and 4.2b of Annex A in the Scope of Work (see Appendix A) require the contractor to gather and analyze data on electrical demand, and to recommend measures for limiting or reducing electrical demand. These requirements are the subjects of §8.2 and 8.3 respectively.

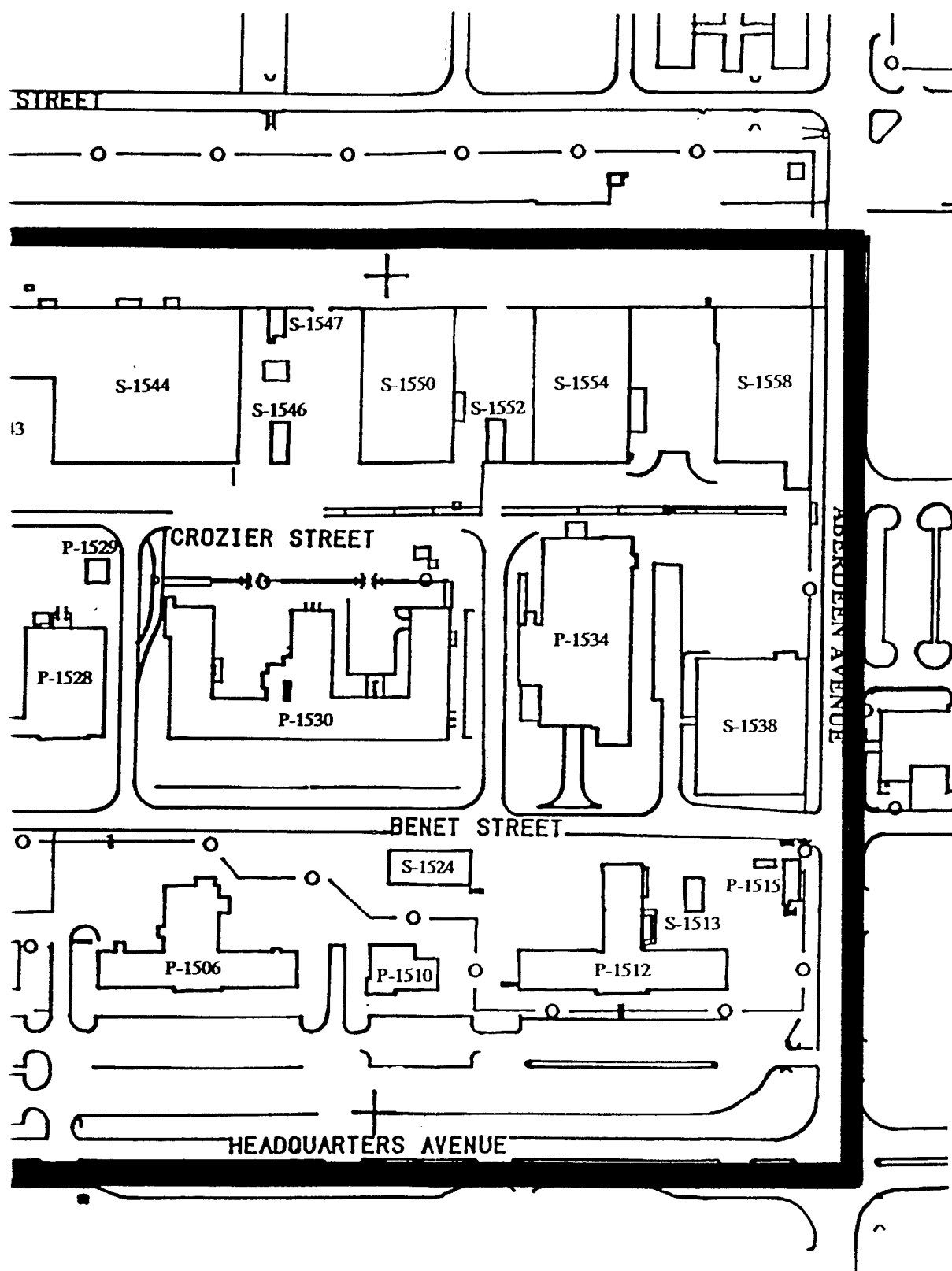
Paragraph 4.2c of Annex B requires two studies for the Tech Area (see Figure 8-1):

- Study the feasibility of installing a consolidated chilled water plant with thermal storage to serve chilled water loads in the Tech Area.
- Study the feasibility of installing a cogeneration system (steam and chilled water) to serve the Tech Area.

Sections 8.4 and 8.5 respectively present the results of these two studies.







③

FIGURE 8-1. TECH AREA SITE MAP

8.2 HISTORICAL ELECTRICAL DEMAND DATA FOR WSMR LOWER RANGE

El Paso Electric Company provides approximately 94% of WSMR's total electric power, and provide service to the Lower Range where the Main Post and Launch Complexes are located. Copies of El Paso Electric Company magnetic tape metering reports for the Main Post were obtained for the months of January, July and October for 1989, 1990, and 1991. The data from the 1991 reports were used to construct typical workday and nonworkday electrical demand profiles, presented in Figures 8-2 through 8-4 starting on page 8-4. The data presented covers only the Main Post Area. Buildings in LC-38 are served by a different substation.

The wintertime weekday on peak demand period begins about 0730 and ends about 1600, which corresponds to the normal day work shift. The demand rise is about 3,000 kW. The wintertime weekend daily demand is fairly constant at about 5000 kW (refer to Figure 8-2).

As indicated in Figure 8-3, the summer nighttime and weekend electrical demand is about 5,000 kW. The weekday workshift rise in demand is about 5,500 kW, which is 2,500 kW greater than in winter, and is attributable to the use of air-conditioning units and evaporative coolers.

The October 1991 electrical demand profiles shown in Figure 8-4 indicate that the early part of October is about the same as July, but by mid-October the daily profile is more like the January profile. The peak October demand is about 11,000 kW, with a workshift demand rise of about 6,000 kW. By late October the daily peak has reduced to 9,000 kW, and the demand rise is about 5,500 kW. This change corresponds directly to the advent of the winter heating season, which normally begins in mid-October. The evaporative coolers are no longer in use, and most of the air-conditioning equipment is turned off by mid-October.

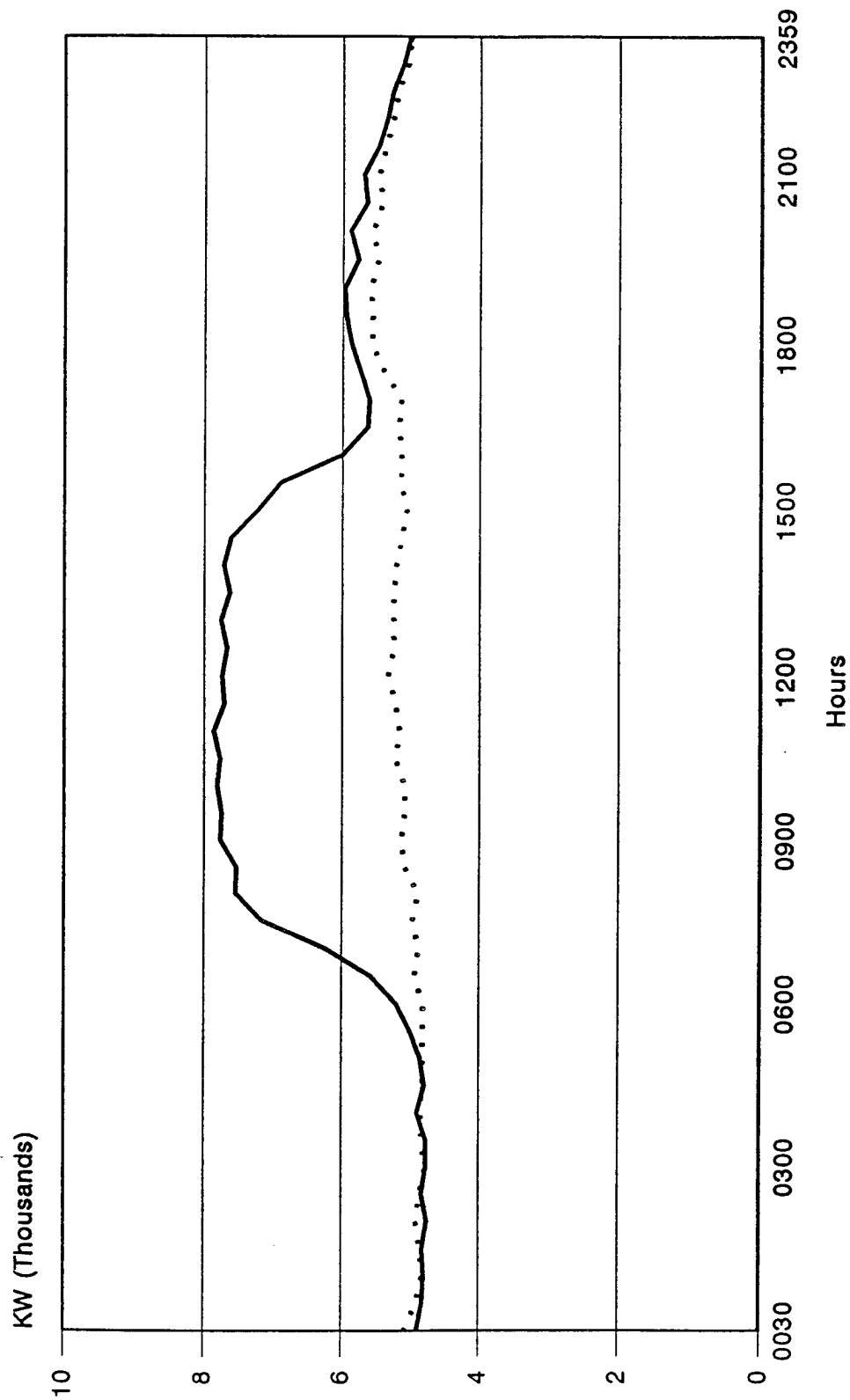
Since there are few January air-conditioning loads (P300 is an exception), the January daily demand rise of about 3,000 kW should correlate to the use of building lights, process equipment, and air handlers, which should be approximately the same throughout the year.

The electrical service contract does not contain a demand ratchet clause. This increases the opportunities for reducing demand charges, as a reduction in any month's electrical peak demand produces savings for that month.

El Paso Electric Company presently has a rebate program for shifted load only. Those DSM projects that a customer undertakes to shift demand from day to night, such as thermal storage, are rebated at \$190.00 per kW.

Workdays	Offpeak kW	On Peak kW	Rise kW
January 1991	5,000	7,800	2,800
July 1991	6,000	11,700	5,700
October 1991	5,000	8,500	3,700
Nonworkdays			
January 1991	5,500	5,300	-200
July 1991	6,000	6,700	700
October 1991	4,800	5,500	700

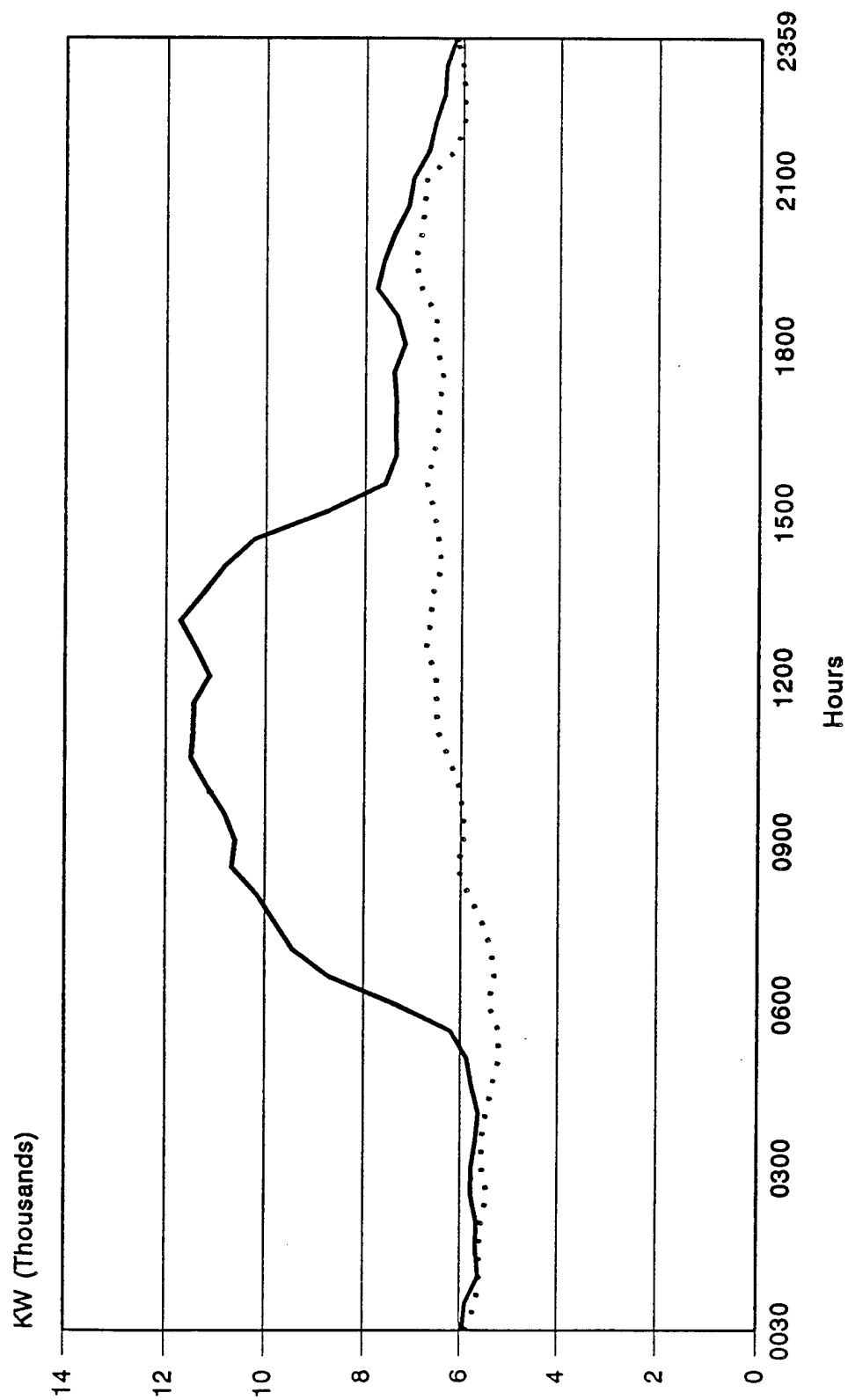
The average El Paso Electric Company peak demand for WSMR is 18,150 kW, and is referred to as the conjunctive peak. It is the sum of peak kW readings recorded at each of the six substations corresponding to the date and time of the highest monthly demand registered. Usually the peak demand occurs at the time the main Post substation peaks. Note that the Main Post Area peak demand occurs in July, and is nominally 11,700 kW, or about two-thirds of the conjunctive peak. The demand profiles at the other 5 substations are relatively flat, so the opportunities for DSM exist primarily at the Main Post Area.



— Mondays · · · Sundays

Source of Data: El Paso Electric Utility Meter Tapes

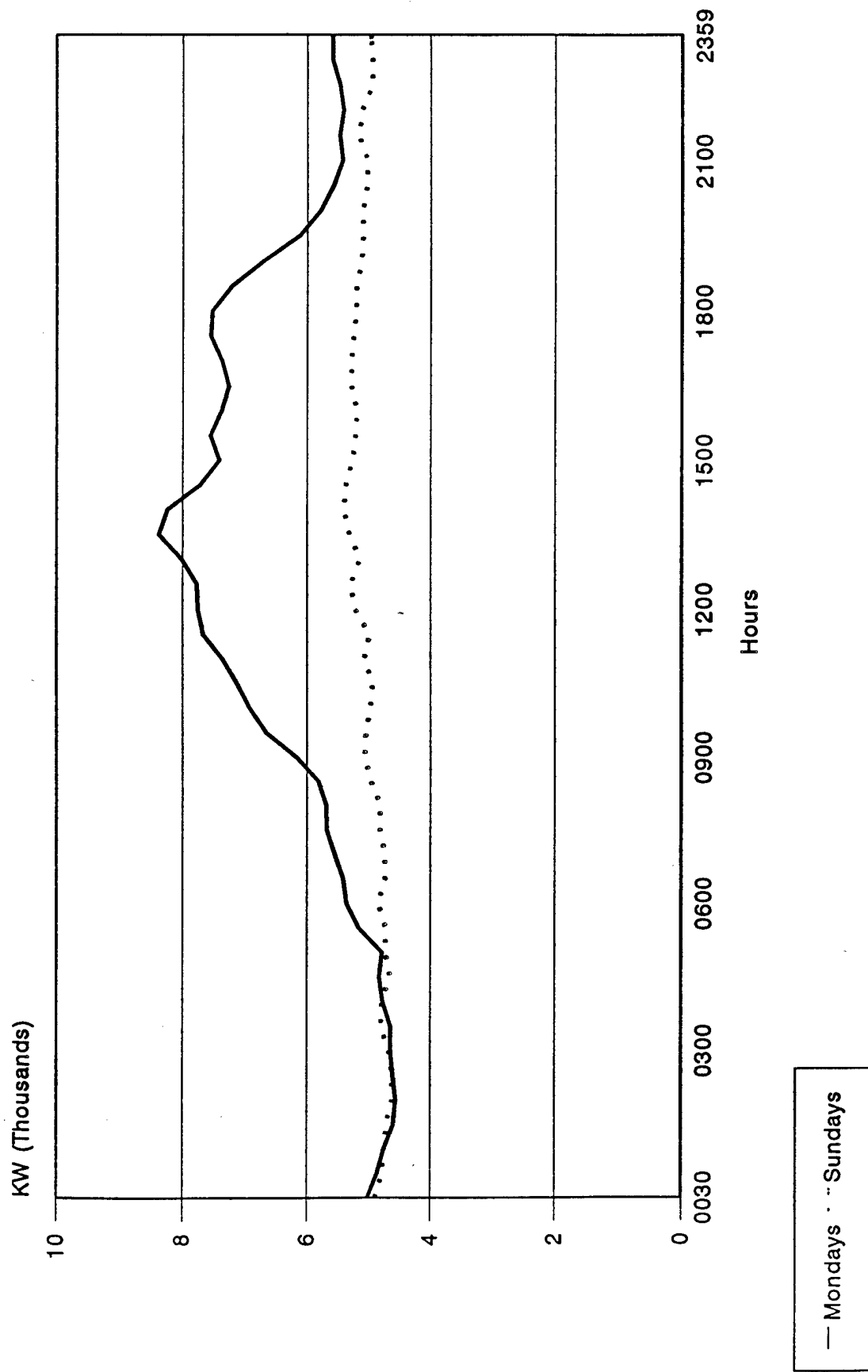
FIGURE 8-2. MAIN POST JANUARY 1991 AVERAGE DEMAND PROFILES



— Mondays ··· Sundays

Source of Data: El Paso Electric Utility Meter Tapes

FIGURE 8-3. MAIN POST JULY 1991 AVERAGE DEMAND PROFILES



Source of Data: El Paso Electric Utility Meter Tapes

FIGURE 8-4. MAIN POST OCTOBER 1991 AVERAGE DEMAND PROFILES

8.3 ANALYSIS

8.3.1 General

Three significant opportunities exist to reduce peak electrical demand at the WSMR without impacting the use of mission equipment.

First and foremost is the opportunity to reduce the connected kW of installed lighting equipment. This is of special importance, as lighting also constitutes a sizeable fraction of the air-conditioning load.

Second is the replacement of standard electric motors with high efficiency motors. The increase in electric motor efficiency varies from 5% for a 1 HP motor to 3.5% for a 5 HP motor, to 2% for a 20 HP motor to 1.5% for a 60 HP motor. While these percentage improvements are small, the accumulated energy and demand savings over the life of the motors are significant. Also, high efficiency motors have more insulation and contain more copper than do standard motors, and last longer.

Third is the scheduled use of chilled water compressor equipment. With properly sized thermal storage, water-cooled and air-cooled chillers may be operated at night, which will reduce peak monthly demand but slightly increase energy consumption. At the current electric company unit prices, thermal storage is very cost effective as a retrofit strategy. In addition to the large cost savings in reducing on peak demand charges, the electric company offers a rebate.

The current El Paso Electric Company rebate policy for thermal storage is \$190/kW of chiller compressor motor load that is shifted to the off-peak period (2000 hours to 1000 hours). The size of the load shift is based on the calculation of the facility (building) annual design cooling load with a conventional compressor operation and with thermal storage. No credit is given for the shifted load of cooling tower and condenser water pump operation.

It is instructive to examine the benefits of a 1 kW reduction in electrical demand at the WSMR. If the reduction is achieved by shifting an electrical load to the off-peak period, there will be demand savings, but no energy savings:

$$1 \text{ kW} \times \$19.50/\text{kW} \times 12 \text{ months} = \$234.00/\text{yr.}$$

If the reduction is achieved by reducing a constant load (a continuously operating motor, for example), then both energy and demand savings accrue:

$$\$234.00 + 8760 \text{ hrs} \times 1 \text{ kW} \times \$0.0221/\text{kWh} = \$427.60/\text{yr.}$$

If the load reduction applies only to normal work shifts, then the annual savings are:

$$\$234.00 + 2080 \text{ hrs} \times 1 \text{ kW} \times \$0.0221/\text{kWh} = \$279.97/\text{yr.}$$

Based on economic return, the order of priorities are:

- Invest in reducing constant electrical loads.
- Invest in reducing workshift electrical loads.
- Invest in shifting loads from the normal workshift to off-peak periods.

8.3.2 Opportunities to Reduce Constant Loads

The following comments relate only to building support systems—lighting, heating, ventilating, air-conditioning, etc. No consideration is given to the operation, modification or replacement of mission equipment.

Certain buildings at the WSMR operate continuously, or at least some parts of some buildings operate continuously. Lighting and space conditioning equipment operate continuously in these areas. Opportunities exist to reduce lighting loads by using more efficient fixtures, increasing the number of lighting circuits, and by reducing lighting to authorized levels. Few opportunities to reduce levels exist, except that a shift to task lighting could be selectively implemented. Opportunities to replace standard motors with high efficiency motors exist.

It is possible to convert certain loads from electricity to natural gas. For example, direct-fired absorption chillers could replace electrically driven equipment. Electric clothes dryers could be replaced by natural gas-fired dryers. The cost of gas at the point-of-use is about \$3.16/MBtu (based on a typical 70% efficiency for a gas appliance) versus \$18.38/MBtu for electric appliances (see Section 2.0). This is 5.8 times as expensive as the cost of a gas-fired appliance. Conversion of appropriate loads from electricity to gas should be given serious consideration where there is practical application.

Another opportunity to reduce peak electrical demand at the WSMR is to adjust the supply airflow rates in buildings to the minimum rates necessary to provide adequate ventilation and space temperature control. The motor power equation for an air handler is:

$$Power (kW) = \frac{0.746}{8512} \times \frac{cfm \times p}{N_m \times N_f}$$

where

- cfm = the supply airflow rate in cubic feet per minute,
p = the total pressure rise across the fan in inches of water gauge,
N_m and =
N_f = the motor and fan operating efficiencies respectively.

The pressure rise across the fan varies with the square of the cfm, so reductions in airflow rate also reduce the pressure rise. The power is proportional to (cfm)³. That is,

$$\frac{kW_1}{kW_2} = \frac{(cfm_1)^3}{(cfm_2)^3}.$$

Just a 15% reduction in airflow rate gives a 38.5% reduction in motor power. There may be many buildings at the WSMR that could use 10% to 15% less supply airflow, which if achieved by resheaving the fans and motor belt drives, would make a significant reduction in peak electrical demand. Conversion of building air systems from constant volume to variable air volume is a way of achieving the maximum reduction in both peak electrical demand and energy consumption, while at the same time reliably meeting annual peak cooling and heating loads.

The same analysis applies to fluid pumping systems. Where variable volume pumping systems make sense, it is very cost effective to convert to variable volume pumping. For example, if it requires 100 kW to operate constant volume pumps that fill a storage tank, and it takes four hours, the demand is 100 kW and the energy is 400 kWh. If time of fill is not critical, a reduction in flow rate of 50% would require an eight hour fill time, but would reduce pump motor kW to $100 \times (1/2)^3$ or 12.5 kW. The demand is reduced by 87.5% and the energy is 12.5 kW \times 8 = 100 kWh, or just one-fourth the constant volume energy requirement.

One possible candidate for variable volume pumping may be the base potable water system. The refilling of the main water storage tank may be an excellent candidate. Neither of these systems are included in the Scope of Work for this study, and were not surveyed or analyzed.

8.4 FEASIBILITY STUDY OF A CONSOLIDATED CHILLED WATER PLANT TO SERVE THE TECH AREA

8.4.1 General

Nine buildings in the Tech Area (see Figure 8-1) are currently served by eight chilled water plants. Each building was modelled on TRACE 600 to obtain a baseline energy consumption, then the nine building cooling load files were consolidated into a single Tech Area cooling load file for use in simulating the various consolidated chiller plant alternatives. The baseline data is presented in Appendix D, Tab 20. A tabulation of the baseline energy data is presented in Table 8-1 on the following page.

TABLE 8-1
TECH AREA BUILDINGS BASELINE DATA

Bldg.	Peak Load (tons)	Installed Capacity (tons)	Building Chilled Water Energy			Annual Gas Consump. (MBtu)	Annual Gas Cost (\$)
			Annual Energy Consump. (kWh)	Sum of Monthly Peak kW	Total (\$)		
1506	100.3	185	128,139	590	14,335	776.1	1,717
1512	116.3	310	244,057	708	19,198	66.6	147
1526	118.9	222	236,737	780	20,432	674.5	1,492
1528	98.5	134	161,327	415	11,662	298.1	660
1530	137.2	222	125,770	684	16,114	922.2	2,040
1621	64.3	150	77,089	347	8,468	96.2	213
1622-23	117.1	131	192,695	755	18,977	881.0	1,949
1624	122.4	161	245,836	702	19,130	100.2	222
TOTAL	875	1,515	1,411,650	4,980.4	128,315	3,814.9	8,440

The monthly ton-hours of chilled water load for the Tech Area and the average monthly tonnage of load are shown in Figure 8-5 on the following page. Note that the chilled water load is seasonal, with a low in January and a high in July. The average load in tons varies from a low of 32 to a high of 258. The peak simultaneous load for the Tech Area is about 550 tons.

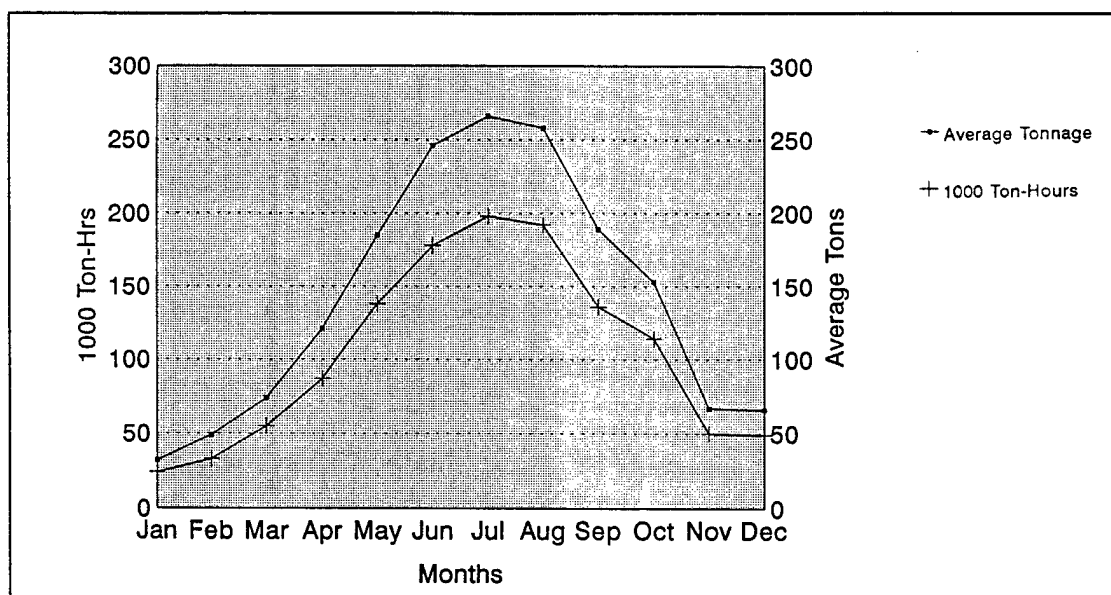


FIGURE 8-5. TECH AREA CHILLED WATER LOAD PROFILE

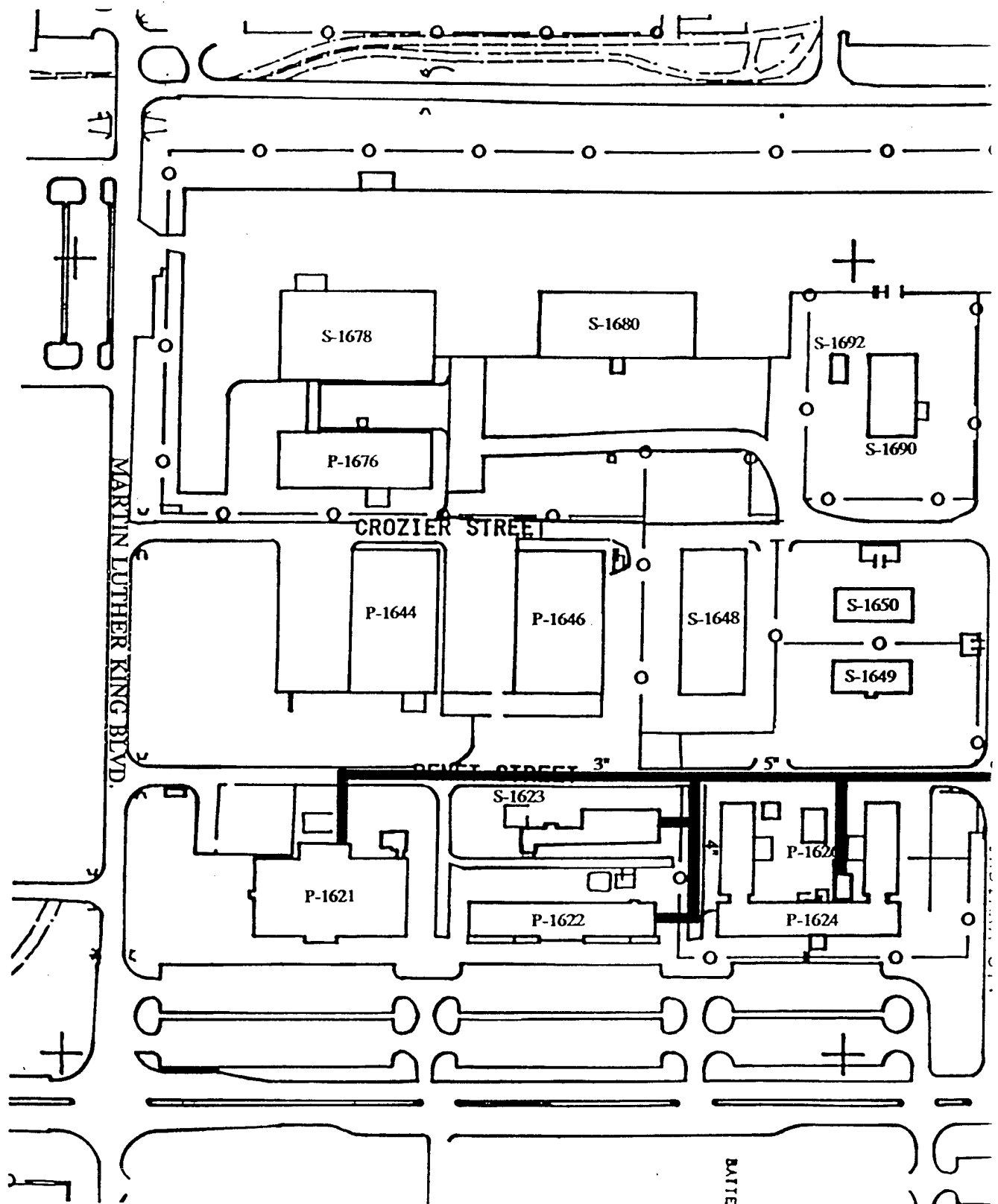
This study considers four alternatives:

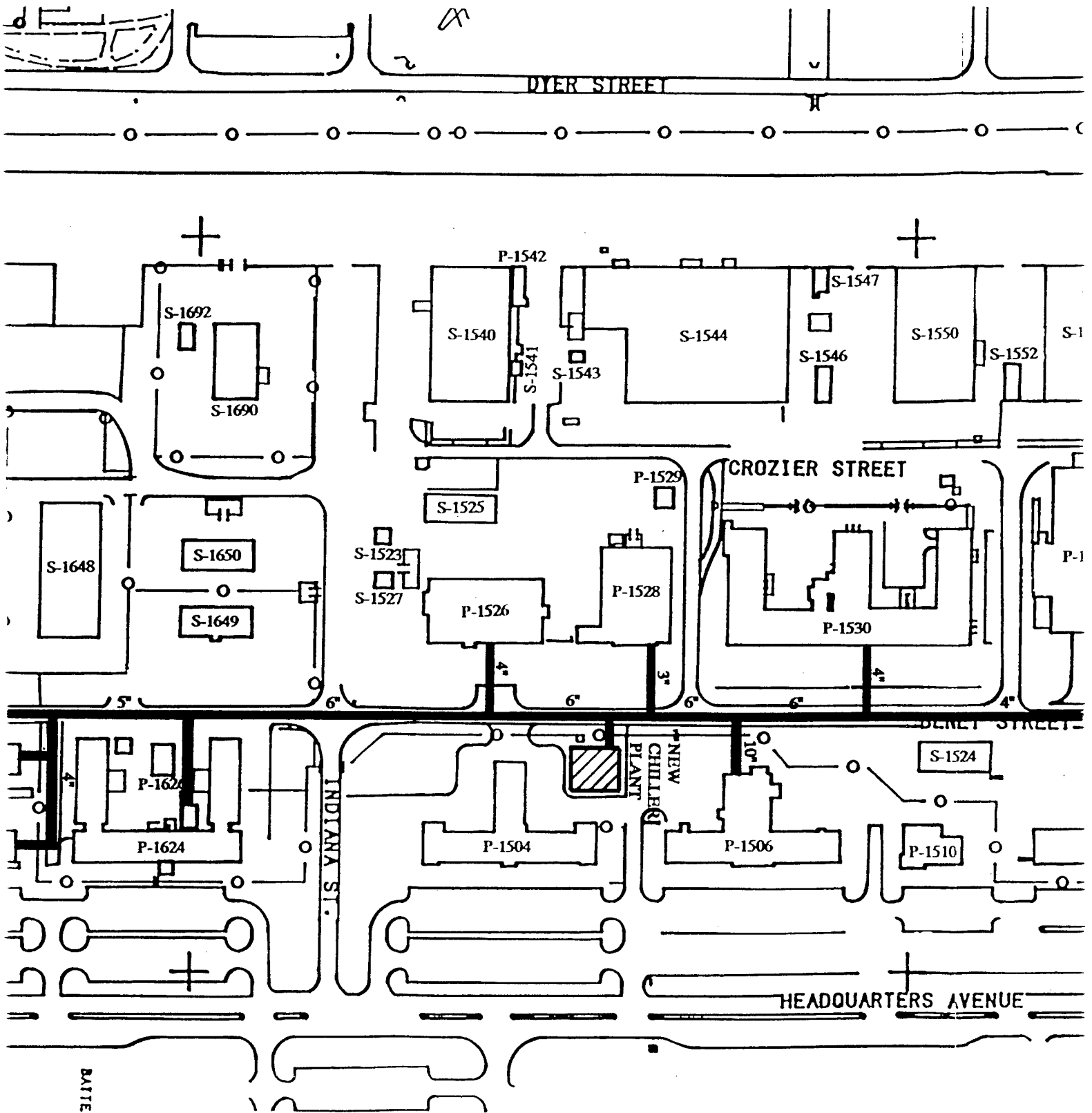
- Alt #1: Consolidated chilled water plant without thermal storage.
- Alt #2: Consolidated chilled water plant with a chilled water storage tank.
- Alt #3: Cogeneration plant - gas turbine engine with heat recovery steam generator and steam turbine-driven centrifugal chillers.
- Alt #4: Cogeneration plant - gas turbine engine with heat recovery steam generator and double effect absorption chillers.

Each alternative includes a new building to house chillers, pumps and motor control centers. Also included are a chilled water piping loop, and a steam and condensate loop (cogeneration only). Only the existing chilled water pumps at the buildings designated in Table 8-1 would continue to operate. All other existing chilled water equipment is assumed to be backup equipment. The steam piping would connect into the existing steam supply network from Building S1544, and would connect to the other Tech Area buildings that currently have their own boilers or gas-fired unit heaters. It is necessary to serve the entire Tech Area space heat, domestic hot water, and process hot water loads in order to make use of the available heat from the gas turbine engine in alternatives 3 and 4.

Each alternative is explained in more detail in the following paragraphs, and all backup data and calculations are included in Appendix D, Tabs 20 through 24 in Volume I Book 2. The baseline performance is included in Tab 20.

The consolidated chilled water plant site and chilled water loop are shown in Figure 8-6 on page 8-13. The steam distribution piping for Alt 3 and Alt 4 is shown in Figure 8-7 on page 8-14.





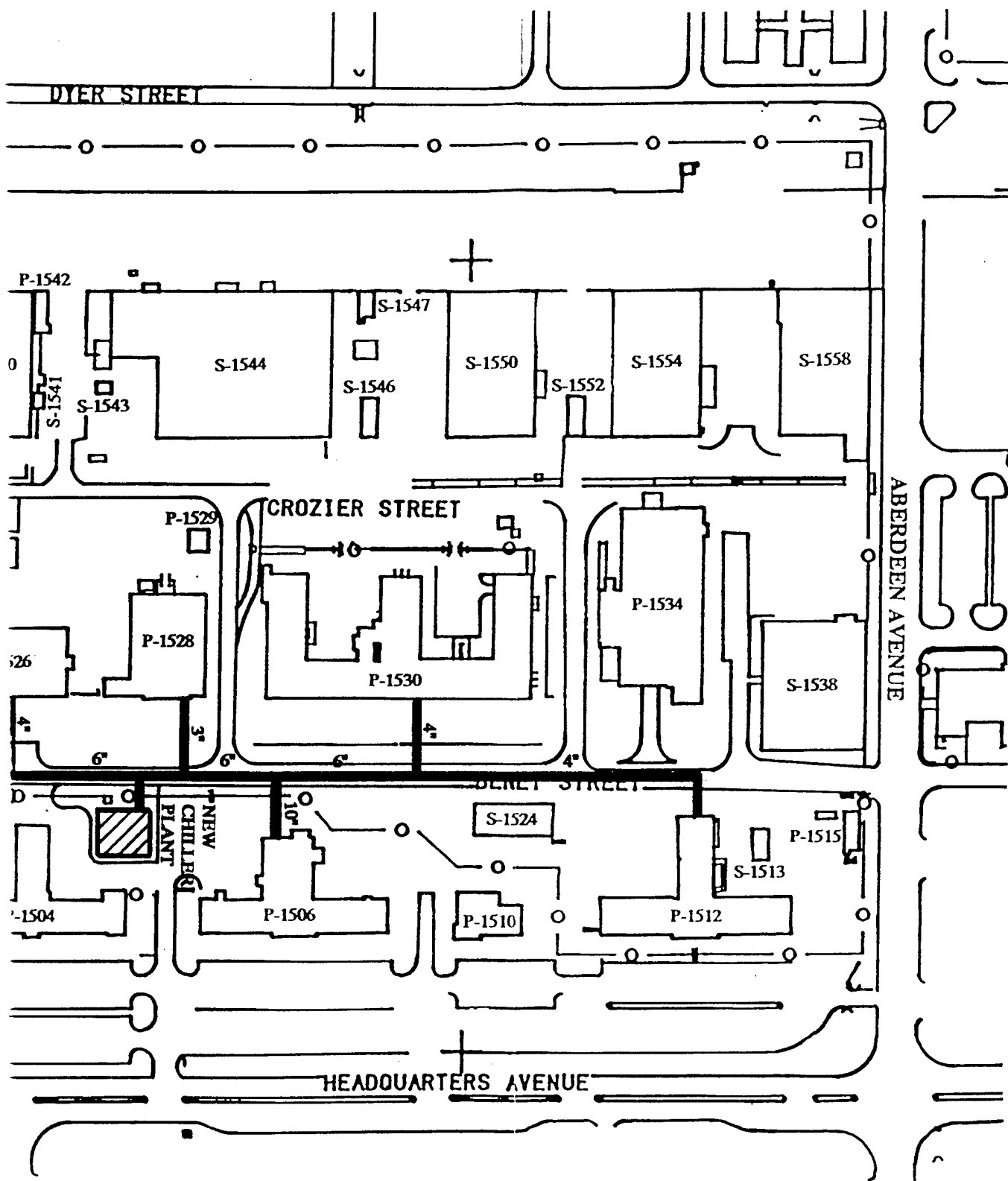
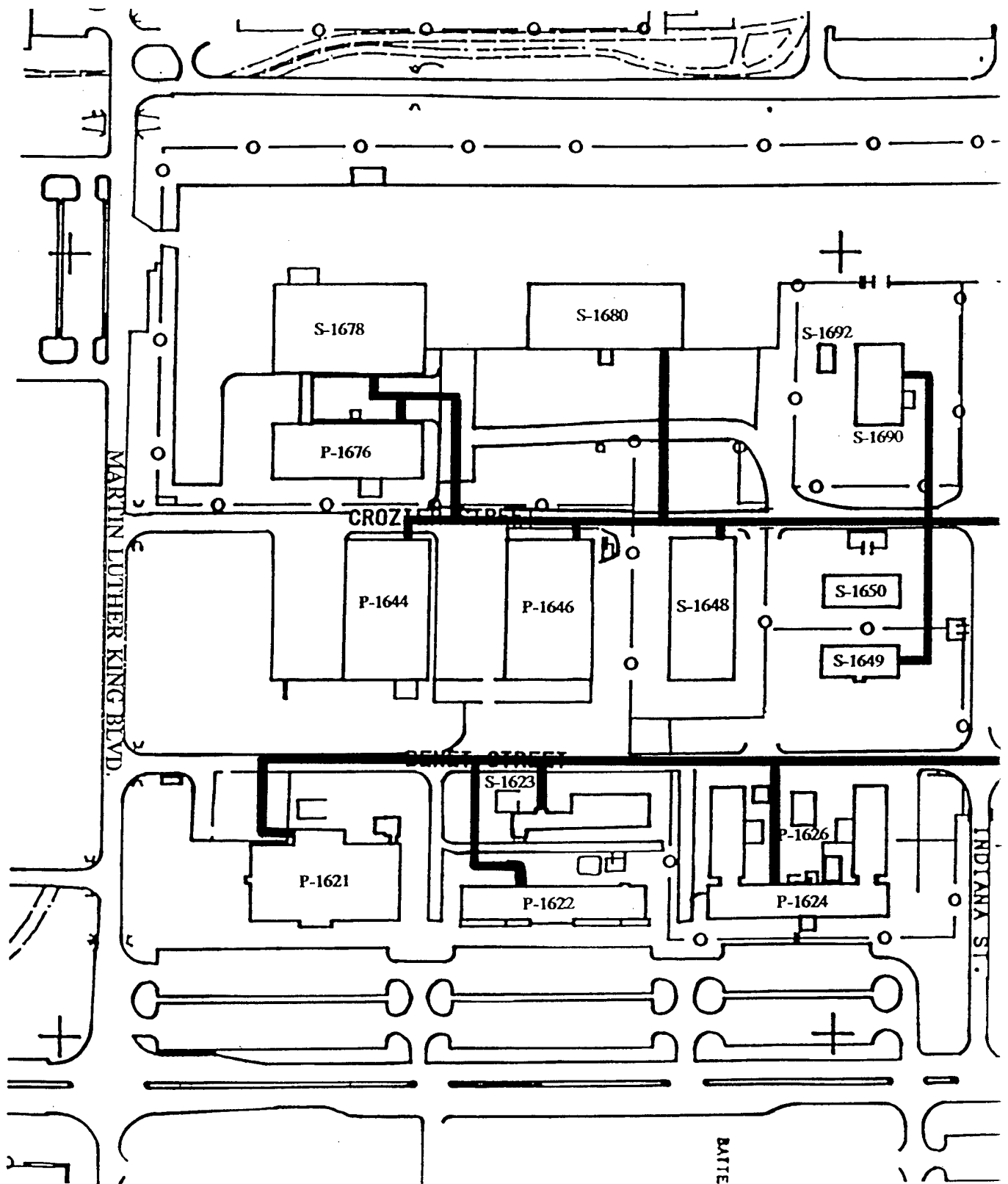
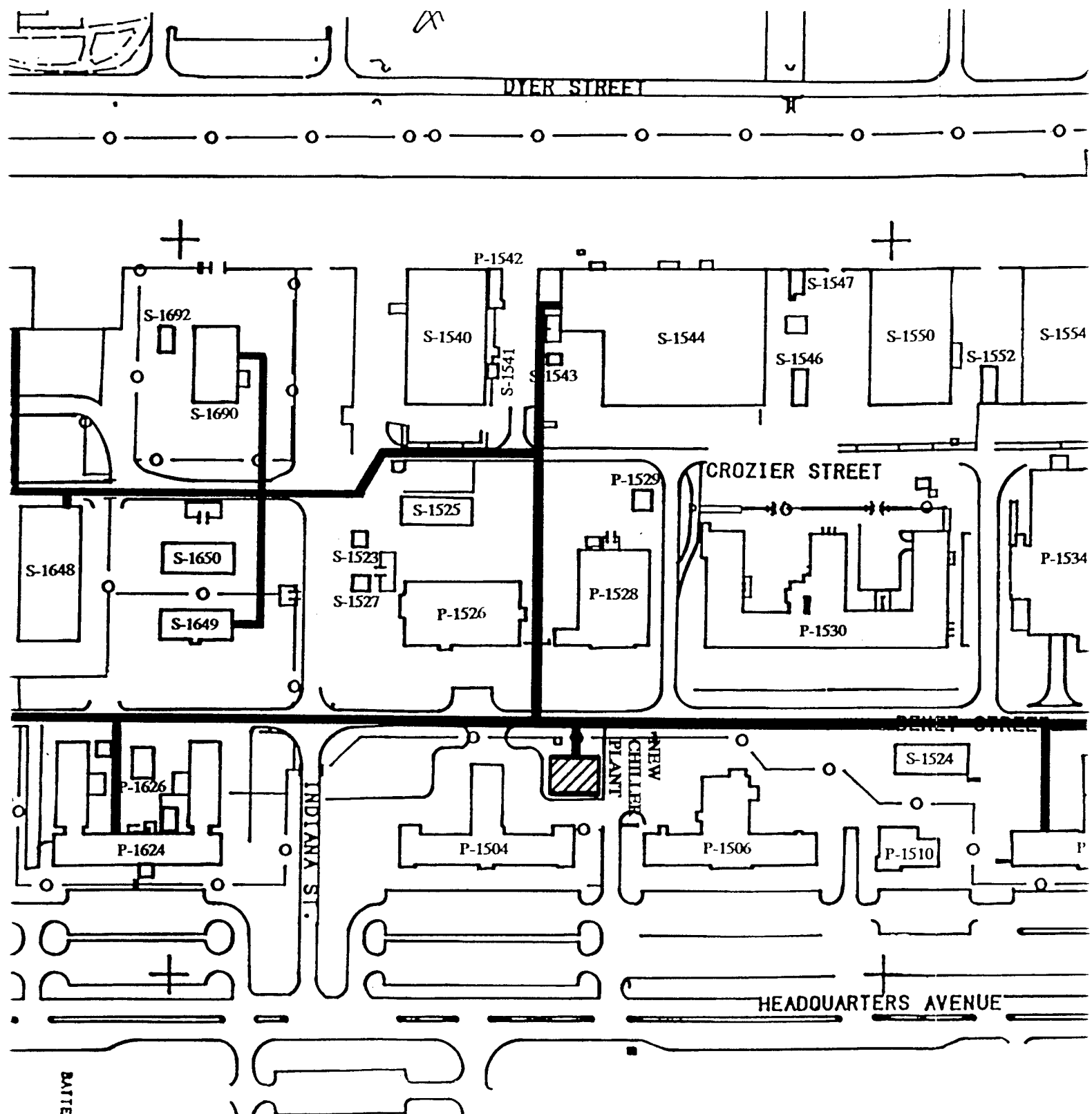


FIGURE 8-6. PLANT SITING AND
CHILLED WATER PIPING
DISTRIBUTION NETWORK

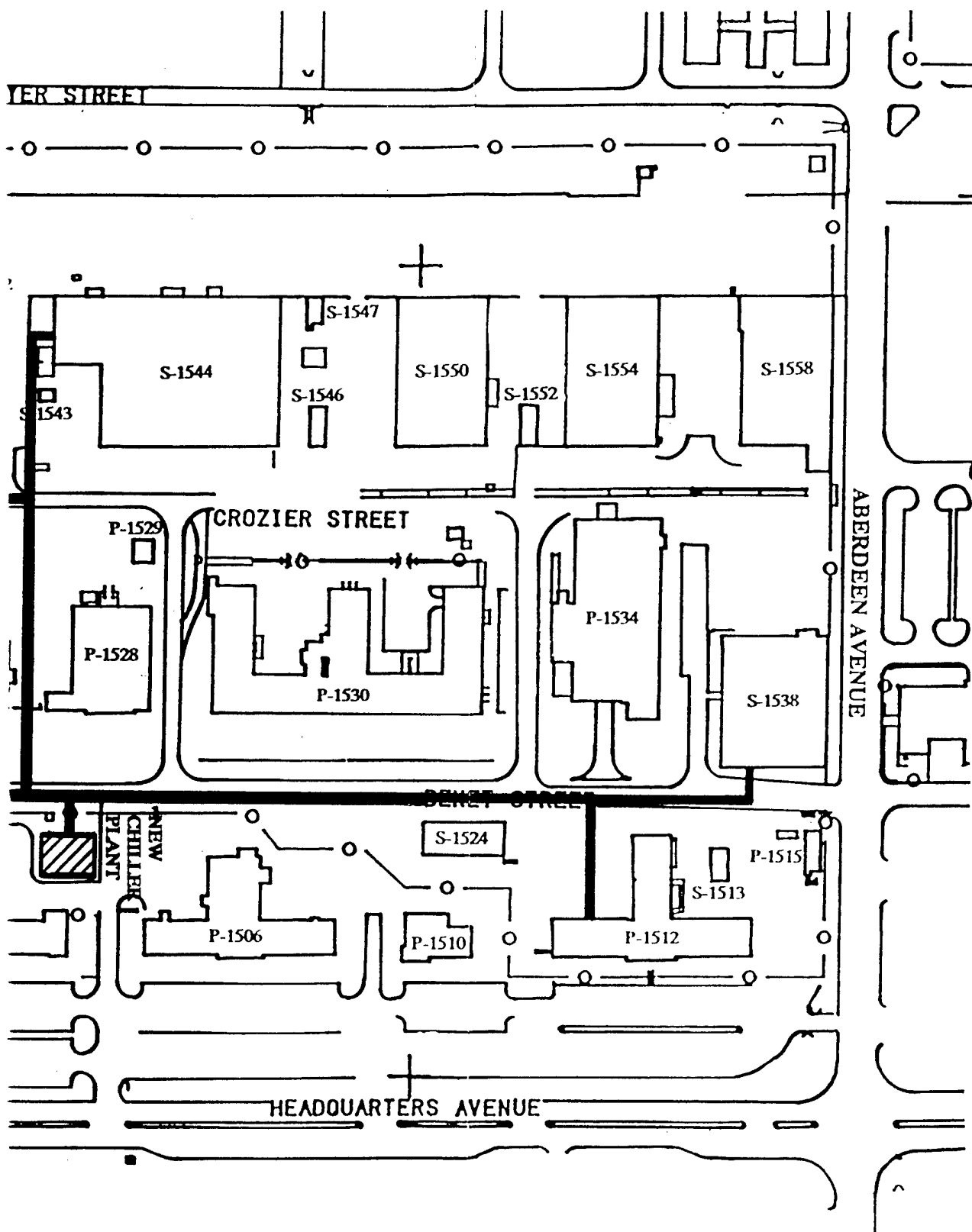
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②

FIGURE 8-7.



③

FIGURE 8-7. STEAM DISTRIBUTION PIPING

8.4.2 Alt. #1

Equipment includes a 175 ton centrifugal chiller, a 375 ton centrifugal chiller, a 660 ton cooling tower, condenser water pumps and chilled water pumps. There is no thermal storage. A plant schematic diagram is shown in Figure 8-8.

The total investment cost for Alt. #1 is \$1,873,939. The chillers and cooling tower cost approximately \$275,000, and the rest of the cost is attributed to the chilled water piping system, interconnections to the nine buildings, pumps and valves, and the building to house the new chiller plant. Annual electric energy cost savings is \$49,559 and demand savings is \$118,502. An equipment cost savings of \$100,000 (avoided replacement costs) is partially offset by an increase in annual maintenance costs of \$20,217. With the nonenergy test requirement for ECIP projects, the SIR is 0.53 and there is no payback period. Without the ECIP non-energy test, the SIR is 1.55 and the simple payback is 10 years.

See Tables 8-2 and 8-3 on page 8-21 for a complete summary of the economic results. The LCCA summary sheet and cost estimate are included in Appendix D, Tab 21 in Volume I Book 2.

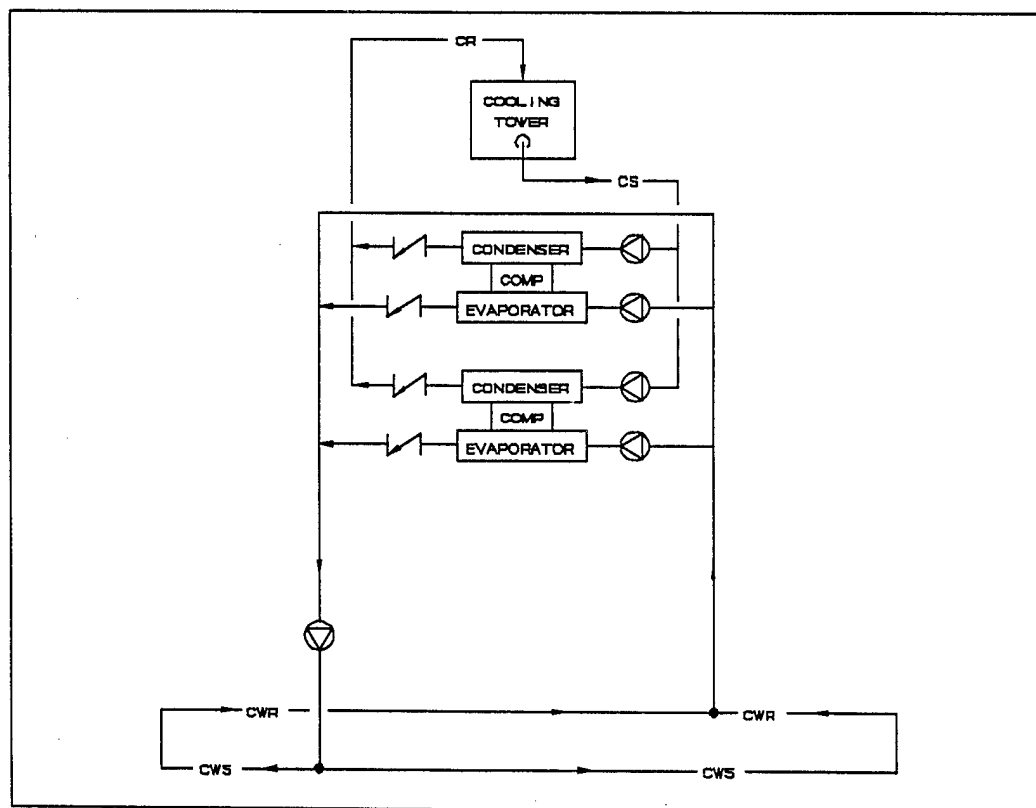


FIGURE 8-8: ALT. #1 SCHEMATIC DIAGRAM

8.4.3 Alt. #2

All plant and distribution equipment is the same as Alt. #1 except that a chilled water thermal storage tank with 6,000 ton-hours of cooling is added. A schematic diagram for Alt. #2 is shown in Figure 8-9 on the following page.

The TRACE 600 model for Alt. #1 was modified to include a 6000 ton-hour chilled water storage tank. The storage temperature was 40°F. The low storage temperature is required to keep the storage volume within practical limits. However, the kW/ton of the chillers is increased from a nominal value of 0.8 to 0.9 during tank charging operation. This increases the annual electrical energy consumption over the baseline consumption by 11%. However, the on peak electrical demand is reduced by 884 kW. The sum of the monthly maximum on peak electrical demand is reduced by 76% from the baseline and 68% from Alt. #1.

The total investment cost for Alt. #2 is \$2,651,693, and the annual maintenance cost increases over the baseline cost by \$41,143. However, the utility rebate for thermal storage plus the avoided replacement costs of existing chilled water equipment over the 25 year life of the project amounts to \$1,174,710. Annual energy cost savings are \$47,981, and demand savings are \$164,366. With the nonenergy cost savings test, the SIR is 0.37 and there is no payback. Without the nonenergy test, SIR is 1.29 and the simple payback is 12.2 years. The high construction cost accounts for the weak economic performance.

A summary of the performance results is presented in Tables 8-2 and 8-3 on page 8-21. The LCCA summary sheet, cost estimate and other backup data are included in Appendix D, Tab 22 in Volume I Book 2.

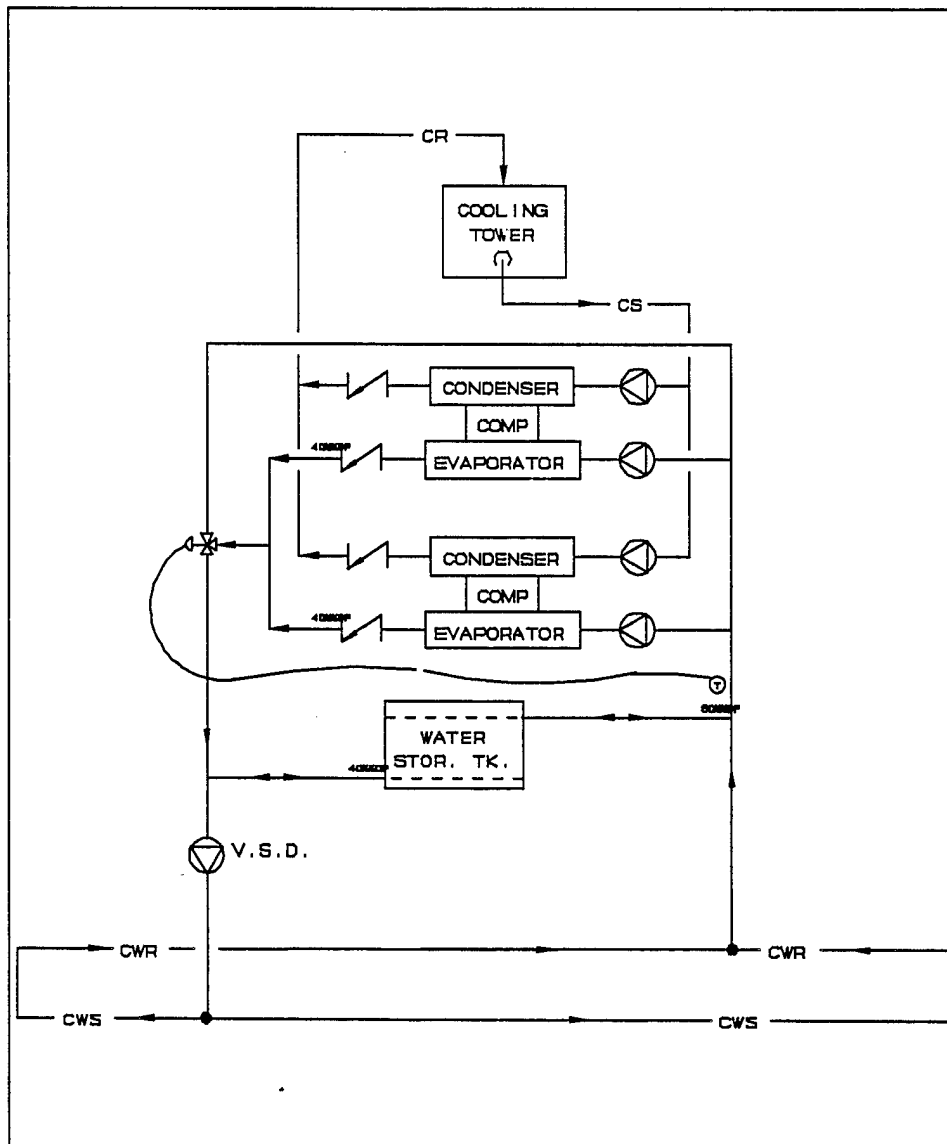


FIGURE 8-9. ALT. #2 SCHEMATIC DIAGRAM

8.4.4 Alt. #3

A schematic diagram for Alt. #3 is shown in Figure 8-10 on the following page. A gas-turbine generator is base loaded to produce constant electric power during the on-peak electrical demand period (1000 hours to 2000 hours daily). Excess electrical power is used to reduce the demand and energy purchased from El Paso Electric Company. Recovered waste heat is used to power steam turbine-driven rotary screw chillers, and to supply the Tech Area with steam for space heating and process loads. An auxiliary boiler augments the Heat Recovery Steam Generator (HRSG), and provides all required steam during the off-peak period.

Two options were considered:

- Option #1: One 500 kW gas-turbine generator set with construction cost of \$4,364,493.
- Option #2: One 875 kW gas-turbine generator set with construction cost of \$4,813,733.

Option #1 results in negative first year dollar savings and negative total discounted savings. The SIR and SPB are both negative. The plant electrical load of 331 kW left only 91 kW to offset the on-peak demand. The electrical revenues generated were insufficient to substantially reduce the on-peak demand.

Option #2 results in positive annual savings, but gives a SIR of 0.01 and SPB of 142 years. The net generated power is 394 kW, but the value of the electrical savings cannot amortize the large steam and chilled water piping costs.

The main obstacle to cost effective cogeneration at the Tech Area is the absence of a sizable steam load to which the waste heat can be applied. The heating and cooling loads occur at different times of the day which results in most of the waste heat being vented to the atmosphere. A second obstacle is the very large cost of installing steam and chilled water distribution piping, and the relatively low utilization of those two systems.

All performance and economic data are summarized in Tables 8-2 and 8-3 on page 8-21. The LCCA summary sheet, cost estimate and other backup data are included in Appendix D, Tab 23 in Volume I Book 2.

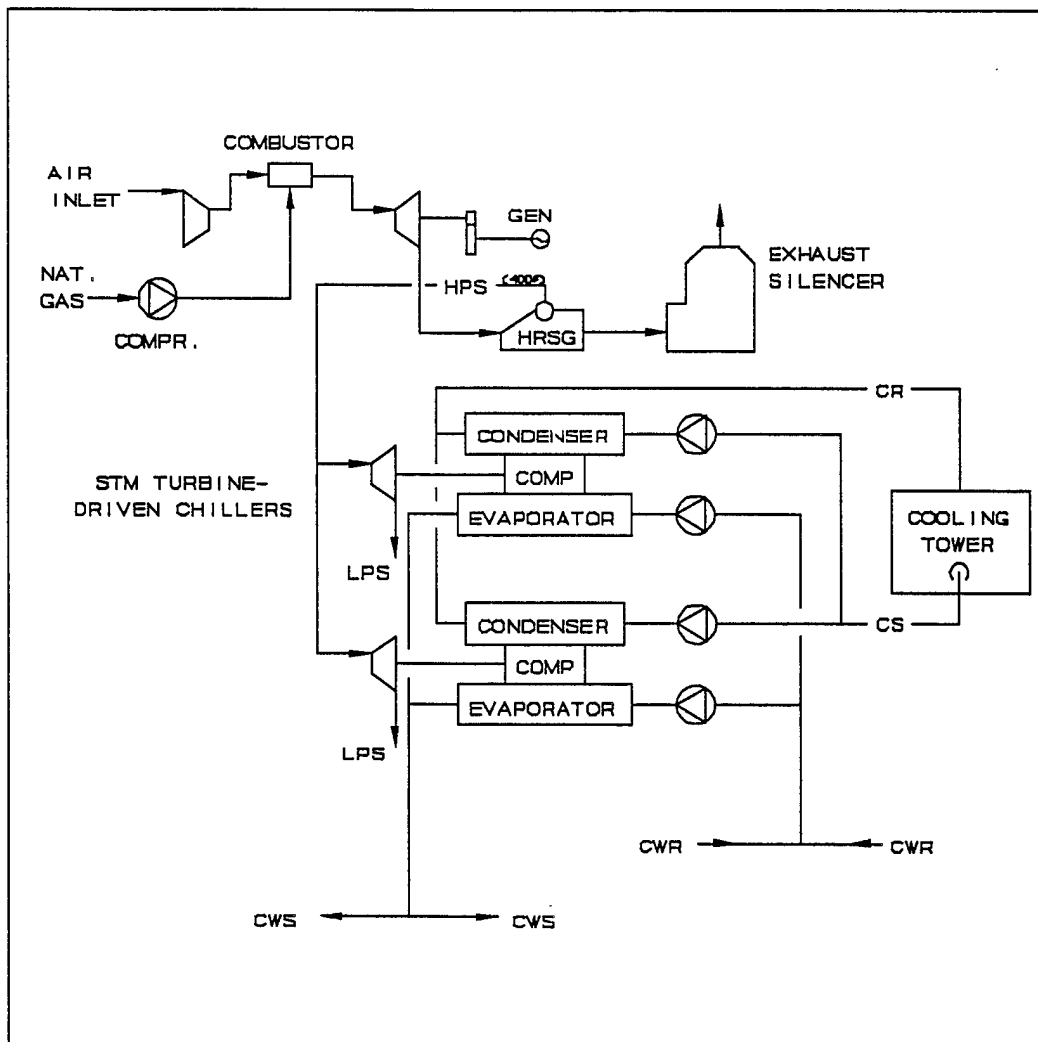


FIGURE 8-10. ALT. #3 SCHEMATIC DIAGRAM

8.5 SUMMARY OF TECH AREA CHILLED WATER PLANT STUDY

A full summary of the performance and economic results is presented in Tables 8-2 and 8-3 below. The performance data include all building electrical loads. The Elec (kW) column presents the sum of the monthly peak kW for a year.

TABLE 8-2
TECH AREA ANNUAL ENERGY USE DATA

	Purchased Utilities			Elec. Energy Savings (kWh)	Reduced Elec. Demand (kW)	Gas Energy Savings (MBtu)
	Elec. (kWh)	Elec. (kW)	Gas (MBtu)			
Baseline	6,682,725	19,679	3,815	0	-	-
Alt #1	4,440,255	13,602	3,815	2,242,470	6,077	0
Alt #2	4,511,648	11,250	3,815	2,171,077	8,429	0
Alt #3	4,881,941	10,427	100,196	1,800,754	9,252	(96,371)
Alt #4	3,230,697	11,619	105,398	3,452,028	8,060	(101,583)

TABLE 8-3
ECONOMIC SUMMARY

Alt. #	Electric Energy (\$/yr)	Electric Demand (\$/yr)	Gas Energy (\$/yr)	Construc. Cost (\$1000)	Rebate (\$)	Maint. Cost (\$/yr)	Simple* Payback (yrs)	SIR*
1	49,559	118,502	0	1,680.7	0	(20,217)	10.0	1.55
2	47,981	164,366	0	2,378.2	167,960	(41,143)	12.2	1.3
3	39,796	180,414	(133,069)	4,813.7	0	(96,371)	142	0.01
4	76,287	157,170	(127,054)	4,592.1	0	(101,583)	114	0.04

Electric energy unit price: \$0.0221/kWh

Electric demand unit price: \$19.50/kW

Natural gas unit price: \$2.2124/MBtu

*SIR and SPB without the nonenergy test.

8.6 CONCLUSIONS AND RECOMMENDATIONS

Both Alt. #1 and Alt. #2 show excellent reductions in annual kWh consumed and in electrical demand. Alt. #1 shows a 33.5% reduction in total building electrical consumption for the 8 buildings with chilled water equipment, and the demand is reduced by 31%. Alt. #2 shows a reduction in total electrical consumption of 32.5% and 43% in demand.

The thermal storage system for Alt. #2 adds about \$700,000 to the consolidated chilled water plant cost, and has a payback by itself of about 14 years. The use of a chilled water storage tank requires the chillers to produce 40° chilled water, which increases the kW/ton from a nominal 0.8 to 0.9. The load shift with thermal storage produces a 42 percent decrease in the chilled water system peak electrical demand, which gives an average monthly demand reduction of 702.4 kW which results in a one time rebate of \$133,459 from the electric company. If all energy and nonenergy cost savings are included, the SIR is 1.3.

The two cogeneration alternatives have negative annual energy savings, and small first year cost savings. The major problem is that the ratio of electrical load to thermal load is too out of balance to utilize a high fraction of the gas turbine exhaust heat. If all the nonenergy cost savings are used in calculating the SIRs, Alt. #3 has an SIR of 0.01 and Alt. #4 has an SIR of 0.04. The simple paybacks are 142 and 114 years respectively. The basic problem is too little cooling in winter and too little heating in summer and high system construction cost.

None of the alternatives is recommended for implementation. A suggested strategy for the chillers serving the Tech Area is to maintain the existing air-cooled chillers, but equip them with precoolers. This will reduce the current peak electrical demand somewhat and also conserve electrical energy.

SECTION 9.0

SUMMARY OF RESULTS AND RECOMMENDATIONS

9.1 GENERAL ECOs

Table 9-1 below lists the general ECOs evaluated for designated buildings.

**TABLE 9-1
ECOS TO BE EVALUATED FOR DESIGNATED BUILDINGS**

ECO #	Short Title	Designated Buildings
2	Add roof insulation	T117, P1830
4	Lower ceiling	P1782, P1830, P1530
7	Install air curtains	P160
9	Replace windows with energy efficient windows	P100, P102, P124, P128, P129, P143, P501, P502, P503, P504
10	Install instantaneous domestic water heaters (point-of-use)	P102, P124, P153, P236, P254, P260, P300, P380, P464, P1504, P1506, P1512, P1526, P1528, P1530, S1558, P1621, P1622, P1624, P1751, S1753, S1790, P1794
12	Replace existing lighting fixtures	P1743, P1751, S1753, S1790, P1794, P1830, P1845
13	Replace old fluorescent fixtures with efficient fixtures, lamps and ballasts	P1743, P1751, S1753, S1790, P1794, P1830, P1845
17	Install infra-red or radiant gas heaters in high bay areas	S1550, S1554, P1644, S1680, P1751, S1753, P1788, P1794, P1827, P1833
19	Install thermostatically controlled radiator/convactor valves	P100, P124
20	Modify heating controls	P100, P124
29	Install a steam booster heater on a dishwasher	P1330
30	Install a boiler for summer domestic hot water load	P236

ECO #4 (lower ceiling) was not evaluated for Buildings P1530 and P1782, as during the survey it was determined that energy would not be saved.

The Consolidated Mess, Building P160, was not evaluated for ECO #7 (air curtains) because air curtains are already installed on the entries and exits.

ECO #10 is not practically feasible for the gymnasium (P236) and the photo lab (P1621). Both buildings have high hot water loads that require storage tanks.

ECO #19 applies to Building P100. ECO #20 applies to P124. Both involve modifying heating controls, and are evaluated as a single ECO.

ECO #29 (install steam booster heater on a dishwasher) was not evaluated at Building P1330 because one is already in place.

The results of the evaluations are shown in Tables 9-2 and 9-3.

**TABLE 9-2
RECOMMENDED GENERAL ECOs**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P124	19-20	Install heating control valves/modify heating controls	747.3	1,779	5,191	3.3	3.8
S1790	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	57.0	369	9,643	5.0	2.9
P1794	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	135.1	875	24,962	5.5	2.7
P1743	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	119.3	773	26,824	6.7	2.2
P1845	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	1.1	7	281	7.4	2.0
P1751	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	38.0	246	9,515	7.5	2.0
P100	19-20	Install heating control valves/modify heating controls	839.4	2,082	12,071	6.5	1.9
P1830	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	45.7	296	12,211	8.0	1.9
S1753	12-13	Replace lighting fixtures with efficient fixtures, lamps and ballasts	26.6	174	7,396	8.2	1.8
T117	2	Add roof insulation	45.6	109	1,450	14.9	1.3
P1794	17	Infrared heaters in high-bay areas	369.4	906	14,602	9.7	1.2
P1788	17	Infrared heaters in high-bay areas	111.8	270	5,677	10.3	1.1
P1827	17	Infrared heaters in high-bay areas	226.0	517	10,695	11.5	1.0
P1751	17	Infrared heaters in high-bay areas	223.3	532	10,584	11.7	1.0

**TABLE 9-3
NONRECOMMENDED GENERAL ECOs**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P1833	17	Infrared heaters in high-bay areas	117.2	278	8,268	13.8	0.8
S1644	17	Infrared heaters in high-bay areas	65.3	232	3,873	13.9	0.8
S1753	17	Infrared heaters in high-bay areas	91.3	221	6,793	14.4	0.8
P502	9	Replace windows with energy efficient windows -grey glass	30.0	187	29,046	17.6	0.8
P502	9	Replace windows with energy efficient windows -clear glass	30.3	196	26,747	21.2	0.7
S1550	17	Infrared heaters in high-bay areas	140.6	531	10,313	18.0	0.6
S1554	17	Infrared heaters in high-bay areas	140.6	531	10,313	18.0	0.6
S1680	17	Infrared heaters in high-bay areas	241.6	577	10,530	20.3	0.6
P501A	9	Replace windows with energy efficient windows -grey glass	33.0	213	42,361	24.2	0.6
P501A	9	Replace windows with energy efficient windows -clear glass	33.0	213	39,008	26.9	0.6
S1790	10	Install instantaneous DHW heaters	28.9	53	2,334	49.2	0.4
P1751	10	Install instantaneous DHW heaters	21.2	39	2,324	67.3	0.3
P1506	10	Install instantaneous DHW heaters	86.3	106	9,176	96.4	0.3
P1512	10	Install instantaneous DHW heaters	37.4	72	8,458	131.8	0.2
P1830	4	Lower ceiling	66.9	114	93,109	124.9	0.1
P124	9	Replace windows with energy efficient windows	312.4	764	102,092	149.0	0.1
P501B	9	Replace windows with energy efficient windows -clear glass	69.0	160	27,507	154.4	0.1
P129	9	Replace windows with energy efficient windows	73.4	240	37,866	175.6	0.1
P143	9	Replace windows with energy efficient windows	73.4	240	37,866	175.6	0.1
P128	9	Replace windows with energy efficient windows	135.9	402	72,187	200.1	0.1
P153	10	Install instantaneous DHW heaters	10.1	11	2,314	243.1	0.1

**TABLE 9-3
NONRECOMMENDED GENERAL ECOs (Concluded)**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
S1753	10	Install instantaneous DHW heaters	9.7	10	2,314	251.2	0.1
P100	9	Replace windows with energy efficient windows	188.2	251	57,602	256.3	0.1
P102	9	Replace windows with energy efficient windows	43.1	101	27,622	305.2	0.1
P504	9	Replace windows with energy efficient windows	46.3	118	32,969	310.4	0.1
P503	9	Replace windows with energy efficient windows	54.9	133	40,750	342.5	0.1
P380	10	Install instantaneous DHW heaters	11.3	21	7,620	400.8	0.1
P1622	10	Install instantaneous DHW heaters	44.2	32	12,378	430.6	0.1
P254	10	Install instantaneous DHW heaters	18.4	10	4,628	529.2	0.1
P1528	10	Install instantaneous DHW heaters	33.3	8	6,234	857.7	0.1
P102	10	Install instantaneous DHW heaters	33.5	10	7,820	891.6	0.1
P124	10	Install instantaneous DHW heaters	36.1	19	16,158	927.4	0.1
P260	10	Install instantaneous DHW heaters	11.9	3	3,830	1382.8	0.1
P1794	10	Install instantaneous DHW heaters	13.6	10	12,374	1410.7	0.1
P300	10	Install instantaneous DHW heaters	78.7	14	20,826	1704.1	0.1
P1624	10	Install instantaneous DHW heaters	39.3	2	10,892	7394.5	0.1
P1504	10	Install instantaneous DHW heaters	27.7	(4)	3,830	N/A	N/A
P464	10	Install instantaneous DHW heaters	9.0	(8)	4,588	N/A	N/A
S1558	10	Install instantaneous DHW heaters	15.2	(13)	7,666	N/A	N/A
P1530	10	Install instantaneous DHW heaters	45.6	(47)	12,408	N/A	N/A
P1526	10	Install instantaneous DHW heaters	7.0	(51)	6,104	N/A	N/A
P1621	10	Install instantaneous DHW heaters	212.0	(1,210)	2,314	N/A	N/A

9.2 BUILDING P300: RANGE CONTROL

The following listed ECOs were designated for P300:

1. Use more efficient lighting fixtures.
2. Reduce lighting levels.
3. Use recovered waste heat.
4. Use dry bulb economizers.
5. Reduce outside air quantities.
6. Use thermal storage for demand reduction.
7. Convert constant volume air handlers to variable air volume.
8. Consolidate multiple air-cooled chillers onto two high-efficiency, water-cooled centrifugal chillers.

ECO #2 was not evaluated because lighting energy conservation is widely practiced in the building. ECO #5 was not evaluated because all makeup air dampers are in the closed position.

Tables 9-4 and 9-5 present the results of the evaluated ECOs.

TABLE 9-4
RECOMMENDED ECOs, P300

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Total Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P300	6	Thermal storage	(224.3)	40,285	165,000	4.6	3.3
P300	8	Convert existing chiller plant to consolidated chiller plant	635.0	4,112	56,100	5.2	2.9
P300	1	Replace lighting fixtures with efficient fixtures, lamps, & ballasts	190.0	1,305	38,783	6.0	2.5
P300	7	Convert existing AHUs to variable-air-volume	4877.6	28,301	268,913	6.0	1.8
P300	ECIP Project	Modified Configuration	5,488	32,367	446,296	4.7	2.3

ECOs 1, 6, 7, and 8 are recommended to be funded as an ECIP project. Project documentation is included in Appendix C. The now entitled "Modified Configuration" presents the economics for the ECIP project.

TABLE 9-5
NONRECOMMENDED ECOS

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Total Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P300	3	Waste heat recovery from chiller plant	2607.8	7,375	91,996	7.4	2.2
P300	4	Dry bulb economizers on AHUs	(798)	3,970	149,536	14.9	0.7

Although ECO #3 qualifies with an SIR of 2.2, it is less attractive than ECO #6, which has an SIR of 3.3. The two ECOs are mutually exclusive, that is, the new modified configuration must have one or the other. ECO #6 is recommended.

9.3 BUILDING ENERGY SURVEYS

Complete energy surveys were performed at Buildings P21140, Temperature Test Facility, P21695, Special Weapons Assembly Building (SWAB), and P24072, Helicopter Drone Maintenance Facility.

The TRACE 600 program was used to model the existing building baseline and ECO configurations. Each of these buildings was constructed as a special use facility, and applicable ECOs are very limited.

Table 9-6 presents baseline energy consumption data, and Tables 9-7 and 9-8 present ECO evaluation results.

**TABLE 9-6
BASELINE ENERGY DATA**

Building	Annual Energy Consumption			Specific (Btu/SF)
	Elec. (kWh)	Elec. Demand (kW)	Gas (MBtu)	
P21140	458,686	94	0	66,250
P21695	252,112	81.3	869.6	99,147
P24072	452,691	61.9	(propane) 659.0	61,989

**TABLE 9-7
RECOMMENDED ECOs, P21140, P21695, P24072**

Bldg. No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P21695	Setback/ thermostats	517.4	1,675	136	0.1	128.0
P24072	Modify HVAC Controls	359.2	2,366	2,016	0.7	16.6
P24072	Replace lighting fixtures with efficient fixtures, lamps & ballasts; disconnect lighting in non- use areas	376.8	2,361	11,338	1.9	6.9
P21140	Replace lighting fixtures with efficient fixtures, lamps & ballasts	1.1	7.3	281	7.4	2.0
P21695	Replace lighting fixtures with efficient fixtures, lamps & ballasts	6.4	90	4,259	8.2	1.8
21140	Reduce stratification	12.8	234	4,077	13.6	1.1

TABLE 9-8
NONRECOMMENDED ECOs, P21140, P21695, 24072

Bldg. No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P24072	Dry-bulb economizer on AHU	10.2	66.2	2,047	21.7	0.5
P21695	Replace windows with energy efficient windows	6.0	29.0	5,107	83.0	0.2
P21695	Dry-bulb economizer on AHU	0.6	5.0	997	242	0.1

9.4 LAUNCH COMPLEX 38

The chilled water plant located in P24066 was surveyed to determine the feasibility of refurbishing the plant and using it to supply P24072, P23638, P23640, and P23642 in Launch Complex 38. It was determined that the condenser water side of the plant is too deteriorated to refurbish and the two 550-ton chillers are much too large in capacity to efficiently supply the load on the four buildings. While, P24066 is adjacent to P24072, it is a mile away from the other three buildings. Piping costs would be prohibitive.

Four chilled water (CW) plant alternatives were identified and evaluated:

- Alt. #1A: Install a CW plant near P23638 with air-cooled chillers to supply the four buildings.
- Alt. #1B: Install a CW plant near P23638 with water-cooled chillers to serve the four buildings.
- Alt. #2A: Install CW plant near P23642 with air-cooled chillers to serve P23638, P23640, and P23642. Use the existing air-cooled chillers at P24072 to serve that building.
- Alt. #2B: The same as for Alt. #2A except use water-cooled chillers in the new plant.

The results are shown in Table 9-9.

**TABLE 9-9
SUMMARY OF ECOs, LC38**

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
LC38 Chiller Plant Study	Alt #2B	130-ton water-cooled chiller plant	4,161	26,966	367,262	7.8	2.2
LC38 Chiller Plant Study	Alt #2A	140-ton air-cooled chiller plant	3,974	25,751	325,091	9.4	1.9
	Alt #1A	200-ton water-cooled chiller plant	4,505	29,190	371,979	11.5	1.6
	Alt #1B	150-ton air-cooled chiller plant	4,691	30,398	703,072	15.8	1.1

At the time of the interim report presentation and review conference (May 28, 1992), it was learned that new air-cooled chillers had been installed at P23640. Also, a work order for new air-cooled chillers for P23638 has been requested. As a result, it is not feasible to proceed with any of the 4 alternatives considered, and none is recommended for implementation.

9.5 CONTRACTOR-IDENTIFIED ECOs

Buildings P23640 and P23642 were constructed as special purpose mission support buildings for the Nike Zeus program, which was discontinued about 30 years ago. The buildings are currently used to support new missions, totally incompatible with the original building designs. Several ECOs at each building were identified that potentially would save energy and correct severe building discrepancies for the current occupants.

In the case of both buildings, a modified configuration consisting of several ECOs was evaluated and compared to the baseline configuration.

Modified Configurations

P23640:

- Upgrade AHU-2 by installing a chilled water coil, repairing the makeup air damper actuator, and installing a dry bulb economizer control.
- Replace the fan motor on AHU-1 with a high efficiency motor and reduce supply airflow rate to 1.5 cfm/SF.

- Optimize the supply air temperature setpoint on AHU-1 and AHU-2.
- Install a 6°F chilled water setpoint reset on the two 50 ton chillers and control the returned chilled water to 55°F.
- Replace standard fluorescent lamps and ballasts with low wattage lamps and ballasts.

P23642:

- Replace standard fluorescent lamps and ballasts with low wattage lamps and ballasts.
- Reduce supply cfm on all 3 AHUs.
- Install dry bulb economizers on all 3 AHUs.
- Replace fan motors on all AHUs with smaller, high efficiency motors.

Results: The baseline and modified configuration were evaluated for each building using the TRACE 600 program. The results for the modified configurations are shown in Table 9-10 below.

TABLE 9-10
RECOMMENDED ECOs, P23640, P23642

Bldg. No.	Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$)	SPB (yrs)	SIR
P23640	Modified configuration	1,065	6,938	15,025	1.1	10.2
P23642	Modified configuration	171	1,104	24,053	4.3	2.5

9.6 DEMAND SIDE MANAGEMENT (DSM)

Copies of El Paso Electric Utility demand meter records for January, July, and October for 1989, 1990 and 1991 were analyzed, and measures to reduce and control on peak electrical demand were recommended.

Typical Demand Profiles: The following data characterize typical workday and nonworkday electrical demand profiles at the Main Post Area. On peak refers to the period from 0730 hours to 1630 hours, and off peak to the rest of the day. The demand kW values shown are nominal maximums.

Workdays	Offpeak kW	On Peak kW	Rise kW
January 1991	5,000	7,800	2,800
July 1991	6,000	11,700	5,700
October 1991	5,000	8,500	3,700
Nonworkdays			
January 1991	5,500	5,300	-200
July 1991	6,000	6,700	700
October 1991	4,800	5,500	700

The average El Paso Electric Company peak demand for WSMR is 18,150 kW, and is referred to as the conjunctive peak. It is the sum of kW demand readings recorded at each of the six substations corresponding to the date and time of the highest monthly demand registered. The peak usually occurs at the time the Main Post substation demand peaks. Note that the Main Post Area peak demand occurs in July, and is nominally 11,700 kW, or about two-thirds of the conjunctive peak. The demand profiles at the other 5 substations are relatively flat, so the opportunities for DSM exist primarily at the Main Post Area.

DSM Opportunities: The significant opportunities to reduce peak electrical demand are shown in the matrix below. The electric service contract contains no demand ratchet clause, which increases opportunities for reducing demand charges.

<u>Opportunity</u>	<u>Priority</u>	<u>Potential Annual Dollars Saved (\$/kW)</u>
Install efficient lighting systems	High	427.60
Thermal storage for chillers	Medium	234.00
Reduce excessive supply airflows	Medium	234.00
Install high efficiency motors	Low	427.60
Convert AHUs to VAV	High	234 to 427.60

At the time of this report submittal, the only DSM rebate available from El Paso Electric Company is \$190.00 per KW of shifted load, which applies only to thermal storage.

9.7 CONSOLIDATED CHILLED WATER PLANT TO SERVE THE TECH AREA

General: Nine buildings in the Tech Area have chilled water systems, and there is a continuous chilled water load in a few buildings. It is necessary to operate some chillers all year long. Most of the existing refrigeration units are air-cooled chillers and are quite inefficient in hot ambient temperature conditions. Four consolidated chilled water plant alternatives were evaluated, each using water-cooled equipment.

- Alt. #1: Consolidated chilled water plant without chilled water thermal storage.
- Alt. #2: Same as Alt. #1 but with chilled water thermal storage.
- Alt. #3: Cogeneration plant with gas turbine-generator set, steam driven rotary chillers, and heat recovery steam generator.
- Alt. #4: Same as Alt. #3 except the chillers are steam powered double effect absorption chillers.

Each alternative includes a chilled water loop to serve the nine buildings, sized for the summer peak load. Alt. #3 and Alt. #4 include a steam and condensate loop that serves all heated buildings in the Tech Area.

Table 9-11 presents the results. None of the alternatives qualifies for implementation under the ECIP guidelines.

TABLE 9-11
NONRECOMMENDED ECOs, TECH AREA

Bldg. No.	ECO No.	ECO Description	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	Construction Cost (\$1,000)	SPB (yrs)	SIR
Technical Area Chiller Plant Study	Alt. #1	Consolidated chiller plant without thermal storage	7,654	49,559	1,681	10	1.55
	Alt. #2	Consolidated chiller plant w/chilled water storage	7,410	47,981	2,378	12.2	1.3
	Alt. #3	Cogeneration plant w/steam turbine-driven chillers	(54,001)	(93,273)	4,814	142	0.01
	Alt. #4	Cogeneration plant w/absorption chillers	(45,646)	(50,767)	4,592	114	0.04

All cost savings are included in the economic evaluation. The nonenergy test was not applied. Alternatives #1 and #2 are cost effective, but have long payback periods and do not qualify for ECIP funding under the current criteria of payback of 8 years or less.

The recommended solution for the Tech Area chilled water systems is to continue to use the existing air-cooled chillers, but to install precoolers on each chiller. This will reduce the kW demand somewhat, and will conserve electrical energy. Replacement with water-cooled equipment would provide better demand reduction, but would significantly increase maintenance and saving requirements, and is therefore not recommended.

SECTION 10.0

SUMMARY OF RECOMMENDED ENERGY RETROFIT PROJECTS

At the interim report presentation and review conference held at the White Sands Missile Range on 28 and 29 May 1992, the following projects were identified for implementation:

- No. 1 Modifications to P300 to include:
- convert air handlers to VAV (§4.11)
 - replace one air-cooled chiller with a water-cooled unit (§4.12)
 - replace all standard 40 watt fluorescent lamps and standard ballasts with reduced wattage lamps and ballasts
 - install a chilled water thermal storage system
- No. 2 Modifications to P24072 (see §5.4) to include:
- improved fluorescent lighting system
 - setback thermostat
 - install cooling coil control valve
- No. 3 Modifications to P23640 (see §7.2) to include:
- improved fluorescent lighting
 - modifications to AHU-2
 - modifications to AHU-1
- No. 4 Modifications to P23642 (see §7.3) to include:
- improved fluorescent lighting
 - modifications to AHU-1
 - modifications to AHU-2 and AHU-3

Only project No. 1, modifications to P300, is to be submitted for ECIP funding. Program documentation for this project is found in Appendix C, Tab 1 in Volume I Book 1.

Projects No. 2 through 4 are to be accomplished with OMA and unit funds as available, and general scopes of work for the construction of these projects are included in Appendix C, Tabs 2 through 4, respectively.

The project energy savings data and economic parameters are presented in Table 10-1.

**TABLE 10-1
DATA SUMMARY FOR ENERGY PROJECTS**

Bldg. No.	Project Description	Construction Cost (\$)	Funding Authority	Energy Savings (MBtu/yr)	Energy Dollar Savings (\$/yr)	SPB (yrs)	SIR
P300	New 100 ton water-cooled chiller and VAV	446,296	ECIP	5,488	32,367	4.7	2.3
P24072	Improve fluorescent lighting, setback thermostat, install cooling coil control valve	13,355	OMA & unit funds	8,662.4	5,741	1.5	7.3
P23640	Improve fluorescent lighting, modify both AHUs	15,025	OMA & unit funds	1,064.7	6,938	1.1	10.2
P23642	Improve fluorescent lighting, modify 3 AHUs to reduce air flow	24,053	OMA & unit funds	171.5	1,103	4.3	2.5

APPENDIX A

**SCOPE OF WORK
SCOPE OF WORK REQUIREMENTS
CONFIRMATION NOTICES**

SCOPE OF WORK
FOR AN
ENERGY SAVINGS OPPORTUNITY SURVEY(ESOS)
FOR
WHITE SANDS MISSILE RANGE, NEW MEXICO

Performed as part of the
ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)

SCOPE OF WORK
FOR AN
ENERGY SAVINGS OPPORTUNITY SURVEY (ESOS)
AT
WHITE SANDS MISSILE RANGE (WSMR), NM

TABLE OF CONTENTS

1. BRIEF DESCRIPTION OF WORK
2. GENERAL
3. PROJECT MANAGEMENT
4. SERVICES AND MATERIALS
5. PROJECT DOCUMENTATION
 - 5.1 ECIP Projects
 - 5.2 Non-ECIP Projects
 - 5.3 Nonfeasible ECOs
6. DETAILED SCOPE OF WORK
7. WORK TO BE ACCOMPLISHED
 - 7.1 Review Previous Studies
 - 7.2 Perform a Limited Site Survey
 - 7.3 Evaluate General Energy Conservation Opportunities
 - 7.4 Evaluate Selected ECOs
 - 7.5 Combine ECOs into Recommended Projects
 - 7.6 Submittals, Presentations and Reviews

ANNEXES

- A - GENERAL ENERGY CONSERVATION OPPORTUNITIES
- B - DETAILED SCOPE OF WORK
- C - EXECUTIVE SUMMARY GUIDELINE
- D - MILESTONES/DATES/PAYMENT SCHEDULE

1. BRIEF DESCRIPTION OF WORK: The Architect-Engineer (AE) shall:

1.1 Review for general information the previously completed Energy Engineering Analysis Program (EEAP) study which was performed at this installation.

1.2 Perform a limited site survey of selected buildings or areas to obtain and/or verify data required to analyze ECOs and to insure that any methods of energy conservation which are practical and have not been evaluated in any previous energy study will be considered and the results documented.

1.3 Evaluate the general energy conservation opportunities (ECOs) of Annex A for the buildings listed in Annex B.

1.4 Evaluate selected ECOs to determine their energy savings potential and economic feasibility.

1.5 Group recommended ECOs into projects for implementation as detailed herein.

1.6 Prepare a comprehensive report to document the work performed, the results and the recommendations.

2. GENERAL

2.1 This study is intended to concentrate on finding and evaluating measures for reducing energy use and/or cost in specific areas and to consider specific ECOs in listed buildings.

2.2 The information and analysis outlined herein are considered to be minimum essentials for adequate performance of this study.

2.3 The AE shall ensure that all methods of energy conservation which will reduce the energy consumption of the installation including those listed in Annexes A and B have been considered and documented. All methods of energy conservation which are reasonable and practical shall be considered, including improvements of operational methods and procedures as well as the physical facilities. All energy conservation opportunities which produce energy or dollar savings shall be documented in this report. Any energy conservation opportunity considered infeasible shall also be documented in the report with reasons for elimination. A list of general energy conservation opportunities to be evaluated for specific buildings or areas is included as Annex A to this scope. Annex B contains a list of ECOs specifically for this installation. Both of these lists shall be considered and the evaluation of each ECO documented in the report. These lists are not intended to be restrictive but only to assure that basic and generally repetitive opportunities are addressed in the report. Some of the energy conservation opportunities in Annex A may not be applicable to the specific building or area at this installation. A statement to that effect is all that is required.

2.4 The study shall include the energy consuming buildings or areas listed in Annex B. The work in the areas may be reduced somewhat by building repetition.

2.5 The study shall consider the use of all energy sources applicable to the installation. The energy sources will include electricity, natural gas, liquefied petroleum gas, oil, gasoline, and solar.

2.6 The "Energy Conservation Investment Program (ECIP) Guidance", described in letter from CEHSC-FU, dated 25 April 1988 and the latest revision from CEHSC-FU establishes criteria for ECIP projects and shall be used for performing the economic analyses of all ECOs and projects. The program, Life Cycle Cost In Design (LCCID), has been developed for performing life cycle cost calculations in accordance with ECIP guidelines and is referenced in the ECIP Guidance. If any program other than LCCID is proposed for life cycle cost analysis, it must use the mode of calculation specified in the ECIP Guidance, the output must be in the format of the ECIP LCCA summary sheet, and it must be submitted for approval to the Contracting Officer.

✓ 2.7 Computer modeling will be used to determine the energy savings of ECOs which would replace or significantly change an existing heating, ventilating, and air conditioning (HVAC) system. This requirement to use computer modeling applies only to heated and air conditioned or air-conditioned-only buildings which exceed 8,000 square feet or heated-only buildings in excess of 20,000 square feet. Modeling will be done using a professionally recognized and proven computer program or programs that integrate architectural features with air-conditioning, heating, lighting and other energy-producing or consuming systems. These programs will be capable of simulating the features, systems, and thermal loads of the building under study. The program will use established weather data files and may perform calculations on a true hour-by-hour basis or may condense the weather files and the number of calculations into several "typical" days per month. The Detailed Scope of Work, Annex B, lists programs that are acceptable to the Contracting Officer. If the AE desires to use a different program, it must be submitted for approval with a sample run, an explanation of all input and output data, and a summary of program methodology and energy evaluation capabilities.

2.8 Energy conservation opportunities determined to be technically and economically feasible shall be developed into projects acceptable to installation personnel. This may involve combining similar ECOs into larger packages which will qualify for ECIP, MCA, or PCIP funding, and determining, in coordination with installation personnel, the appropriate packaging and implementation approach for all feasible ECOs.

2.8.1 Projects which qualify for ECIP funding shall be identified, separately listed, and prioritized by the Savings to Investment Ratio (SIR).

2.8.2 All feasible non-ECIP projects shall be ranked in order of highest to lowest SIR.

PROJECT MANAGEMENT

3.1 Project Managers. The AE shall designate a project manager to serve as a point of contact and liaison for work required under this contract. Upon award of this contract, the individual shall be immediately designated in writing. The AE's designated project manager shall be approved by the Contracting Officer prior to commencement of work. This designated individual shall be responsible for coordination of work required under this contract. The Contracting Officer will designate a project manager to serve as the Government's point of contact and liaison for all work required under this contract. This individual will be the Government's representative.

3.2 Installation Assistance. The Commanding Officer or authorized representative at the installation will designate an individual who will serve as the point of contact for obtaining information and assisting in establishing contacts with the proper individuals and organizations as necessary to accomplish the work required under this contract. This individual will be the installation representative.

3.3 Public Disclosures. The AE shall make no public announcements or disclosures relative to information contained or developed in this contract, except as authorized by the Contracting Officer.

3.4 Meetings. Meetings will be scheduled whenever requested by the AE or the Contracting Officer for the resolution of questions or problems encountered in the performance of the work. The AE and/or the designated representative(s) shall be required to attend and participate in all meetings pertinent to the work required under this contract as directed by the Contracting Officer. These meetings, if necessary, are in addition to the presentation and review conferences.

3.5 Site Visits, Inspections, and Investigations. The AE shall visit and inspect/investigate the site of the project as necessary and required during the preparation and accomplishment of the work.

3.6 Records

3.6.1 The AE shall provide a record of all significant conferences, meetings, discussions, verbal directions, telephone conversations, etc., with Government representative(s) relative to this contract in which the AE and/or designated representative(s) thereof participated. These records shall be dated and shall identify the contract number, and modification number if applicable, participating personnel, subject discussed and conclusions reached. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the records.

3.6.2 The AE shall provide a record of requests for and/or receipt of Government-furnished material, data, documents, information, etc., which if not furnished in a timely manner, would significantly impair the normal progression of the work under this contract. The records shall be dated and shall identify the contract number and modification number, if applicable. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the record of request or receipt of material.

3.7 Interviews. The AE and the Government's representative shall conduct entry and exit interviews with the Director of Engineering and Housing before starting work at the installation and after completion of the field work. The Government's representative shall schedule the interviews at least one week in advance.

3.7.1 Entry. The entry interview shall thoroughly describe the intended procedures for the survey and shall be conducted prior to commencing work at the facility. As a minimum, the interview shall cover the following points:

- a. Schedules.
- b. Names of energy analysts who will be conducting the site survey.
- c. Proposed working hours.
- d. Support requirements from the Director of Engineering and Housing.

3.7.2 Exit. The exit interview shall include a thorough briefing describing the items surveyed and probable areas of energy conservation. The interview shall also solicit input and advice from the Director of Engineering and Housing.

4. SERVICES AND MATERIALS. All services, materials (except those specifically enumerated to be furnished by the Government), plant, labor, superintendence and travel necessary to perform the work and render the data required under this contract are included in the lump sum price of the contract.

5. PROJECT DOCUMENTATION. All energy conservation opportunities which the AE has considered shall be included in one of the following categories and presented in the report as such:

5.1 ECIP Projects. To qualify as an ECIP project, an ECO, or several ECOs which have been combined, must have a construction cost estimate greater than \$200,000, a Savings to Investment Ratio greater than one and a simple payback period of less than eight years. The overall project and each discrete part of the project shall have an SIR greater than one. All projects meeting the above criteria shall be arranged as specified in paragraph 2.8.1 and provided with the following documentation: life cycle cost analysis (LCCA) summary sheet, description of the work to be

accomplished, backup data for the LCCA, ie, energy savings calculations and cost estimate(s), and the simple payback period. The energy savings for projects consisting of multiple ECOs must take to account the synergistic effects of the individual ECOs.

5.2 Non-ECIP Projects. Projects which do not meet ECIP criteria with regard to cost estimate, payback period, or nonenergy (75%) qualification test, but which have an SIR greater than one shall be documented. Projects or ECOs in this category shall be arranged as specified in paragraph 2.8.2 and provided with the following documentation: the life cycle cost analysis (LCCA) summary sheet completely filled out, a description of the work to be accomplished, backup data for the LCCA, ie, energy savings calculations and cost estimate(s), and the simple payback period. The energy savings for projects consisting of multiple ECOs must take into account the synergistic effects of the individual ECOs. Additionally, these projects shall be grouped in accordance with the requirements of the Government's representative, for one of the following categories:

a. Quick Return on Investment Program (QRIP). This program is for projects which have a total cost not over \$100,000 and a simple payback period of two years or less.

b. OSD Productivity Investment Funding (OSD PIF). This program is for projects which have a total cost of more than \$100,000 and a simple payback period of four years or less.

c. Productivity Enhancing Capital Investment Program (PE-P). This program is for projects which have a total cost of more than \$3,000 and a simple payback period of four years or less.

The above programs are all described in detail in AR 5-4, Change No. 1.

d. Regular Military Construction Army (MCA) Program. This program is for projects which have a total cost greater than \$200,000 and a simple payback period of eight to twenty-five years.

e. Low Cost/No Cost Projects. These are projects which can be done using DEH resources.

5.3 Nonfeasible ECOs. All ECOs which the AE has considered but which are not feasible, shall be documented in the report with reasons and justifications showing why they were rejected.

6. DETAILED SCOPE OF WORK. The detailed Scope of Work is contained in Annex B.

7. WORK TO BE ACCOMPLISHED.

7.1 Review Previous Studies. The AE shall review for general information the previous EEAP study. This review should acquaint

the AE with the work that has been performed previously. Much of the information the AE may need to develop the ECOs in this project may be contained in the previous study. The survey data from the previous study also may be helpful.

7.2 Perform a Limited Site Survey. The AE shall obtain all necessary data to evaluate the ECOs or projects by conducting a site survey. However, the AE is encouraged to use any data that may have been documented in a previous study. The AE shall document his site survey on forms developed for the survey, or standard forms, and submit these completed forms as part of the report. All test and/or measurement equipment shall be properly calibrated prior to its use.

7.3 Evaluate General Energy Conservation Opportunities. The list of ECOs in Annex A shall be evaluated for the buildings or areas of Annex B. This list is not intended to be restrictive but only to assure that these opportunities, as a minimum, are considered, discussed and documented in the report. The AE may be aware of other ECOs not included in Annex A that will produce energy, manpower or dollar savings. These should be evaluated the same as the other ECOs. Each of the items shall be considered and discussed in the report. Those items on the list which are not practical, have been previously accomplished, are inappropriate or can be eliminated from detailed analysis based on preliminary analysis shall be listed in the report along with the reason for elimination from further analysis. All potential ECOs which are not eliminated by preliminary considerations shall be thoroughly documented and evaluated as to technical and economic feasibility.

7.4 Evaluate Selected ECOs. The AE shall analyze the ECOs listed in Annex B. These ECOs shall be analyzed in detail to determine their feasibility. Savings to Investment Ratios (SIRs) shall be determined using current ECIP guidance. The AE shall provide all data and calculations needed to support the recommended ECO. All assumptions shall be clearly stated. Calculations shall be prepared showing how all numbers in the ECO were figured. Calculations shall be an orderly step-by-step progression from the first assumption to the final number. Descriptions of the products, manufacturers catalog cuts, pertinent drawings and sketches shall also be included. A life cycle cost analysis summary sheet shall be prepared for each ECO and included as part of the supporting data.

7.5 Combine ECOs Into Recommended Projects. During the Interim Review Conference, as outlined in paragraph 7.6.1, the AE will be advised of the DEH's preferred packaging of recommended ECOs into projects for implementation. Some projects may be a combination of several ECOs, and others may contain only one. These projects will be evaluated and arranged as outlined in paragraphs 5.1, 5.2, and 5.3. Energy savings calculations shall take into account the synergistic effects of multiple ECOs within a project and the effects of one project upon another. The results of this effort will be reported in the Prefinal Submittal per paragraph 7.6.2.

7.6 Submittals, Presentations and Reviews. The work accomplished shall be fully documented by a comprehensive report. The report shall have a table of contents and shall be indexed. Tabs and dividers shall clearly and distinctly divide sections, subsections, and appendices. All pages shall be numbered. Names of the persons primarily responsible for the project shall be included. The AE shall give a formal presentation of all but the final submittal to installation, command, and other Government personnel. Slides or view graphs showing the results of the study to date shall be used during the presentation. Hard copies of the presentation graphics shall be available for the conference attendees. During the presentation, the personnel in attendance shall be given ample opportunity to ask questions and discuss any changes deemed necessary to the study. A review conference will be conducted the same day, following the presentation. Each comment presented at the review conference will be discussed and resolved or action items assigned. The AE shall provide the comments from all reviewers and written notification of the action taken on each comment to all reviewing agencies within three weeks after the review meeting. It is anticipated that each presentation and review conference will require approximately one working day. The presentation and review conferences will be at the installation on the date(s) agreeable to the Director of Engineering and Housing, the AE and the Government's representative. The Contracting Officer may require a resubmittal of any document(s), if such document(s) are not approved because they are determined by the Contracting Officer to be inadequate for the intended purpose.

7.6.1 Interim Submittal. An interim report shall be submitted for review after the field survey has been completed and an analysis has been performed on all of the ECOs. The report shall indicate the work which has been accomplished to date, illustrate the methods and justifications of the approaches taken and contain a plan of the work remaining to complete the study. Calculations showing energy and dollar savings, SIR, and simple payback period of all the ECOs shall be included. The results of the ECO analyses shall be summarized by lists as follows:

a. All ECOs eliminated from consideration shall be grouped into one listing with reasons for their elimination as discussed in paragraph 7.3.

b. All ECOs which were analyzed shall be grouped into two listings, recommended and non-recommended, each arranged in order of descending SIR. These lists may be subdivided by building or area as appropriate for the study.

The AE shall submit the Scope of Work and any modifications to the Scope of Work as an appendix to the report. A narrative summary describing the work and results to date shall be a part of this submittal. At the Interim Submittal and Review Conference, the Government's and AE's representatives shall coordinate with the Director of Engineering and Housing to provide the AE with direction for packaging or combining ECOs for programming purposes. The survey forms completed during this audit shall be submitted with this report. The survey forms only may be submitted in final form

with this submittal. They should be clearly marked at the time of submission that they are to be retained. They shall be bound in a standard three-ring binder which will allow repeated disassembly and reassembly of the material contained within.

7.6.2 Prefinal Submittal. The AE shall prepare and submit the prefinal report when all sections of the report are complete. Any revisions or corrections resulting from comments made during the review of the interim report or during the presentation and review conference shall be incorporated into the prefinal report. The AE shall submit the Scope of Work for the installation studied and any modifications to the Scope of Work as an appendix to the submittal. The report shall contain a narrative summary of conclusions and recommendations, together with all raw and supporting data, methods used, and sources of information. The report shall integrate all aspects of the study. The recommended projects, as determined in accordance with paragraph 7.5, shall be presented in order of priority by SIR. The lists of ECOs specified in paragraph 7.6.1 shall also be included for continuity. The prefinal report and all appendices shall be bound in standard three-ring binders which will allow repeated disassembly and reassembly. The prefinal submittal shall be arranged to include (a) a separately-bound Executive Summary to give a brief overview of what was accomplished and the results of this study using graphs, tables and charts as much as possible (See Annex C for minimum requirements), (b) the narrative report containing a copy of the Executive Summary at the beginning of the volume and describing in detail what was accomplished and the results of this study, (c) documentation for the recommended projects, and (d) appendices to include the detailed calculations and all backup material. A list of all projects and ECOs developed during this study shall be included in the Executive Summary and shall include the following data from the life cycle cost analysis summary sheet: the cost (construction plus SIOH), the annual energy savings (type and amount), the annual dollar savings, the SIR, the simple payback period and the analysis date.

7.6.3 Final Submittal. Any revisions or corrections resulting from comments made during the review of the prefinal report or during the presentation and review conference shall be incorporated into the final report. These revisions or corrections may be in the form of replacement pages, which may be inserted in the prefinal report, or complete new volumes. Pen and ink changes or errata sheets will not be acceptable. If replacement pages are to be issued, it shall be clearly stated with the prefinal submittal that the submitted documents will be changed only to comply with the comments made during the prefinal conference and that the volumes issued at the time of the prefinal submittal should be retained. Failure to do so will require resubmission of complete volumes. If new volumes are submitted, they shall be in standard three-ring binders and shall contain all the information presented in the prefinal report with any necessary changes made. Detailed instructions of what to do with the replacement pages must be securely attached to the replacement pages.

ANNEX A

GENERAL ENERGY CONSERVATION OPPORTUNITIES

1. Insulation (wall, roof, pipe, duct, etc)
2. Insulation (roof only)
3. Weatherstripping and caulking.
4. Lower ceiling.
5. Insulated panels.
6. Loading dock seals.
7. Air curtains.
8. Reduce glass area.
9. Replace existing windows with energy efficient windows; consider both double pane windows and/or "E" glass where appropriate.
10. Instantaneous hot water heater for men's and women's restrooms per floor. Heaters to be sized to provide hot water to maximum of one shower per men's/women's restroom per building, two (2) wash basins per restroom, and janitor's closet if applicable.
11. Thermostatically control hot water circulation pump.
- * 12. Replace existing fixtures with more efficient lighting source.
- * 13. Replace old fluorescent fixtures with energy conserving fluorescent lamps, ballasts, and reflectors.
14. Separate switches to control lighting arrangements.
15. Photocells to control exterior lighting.
16. Occupancy sensors to control lighting or HVAC.
17. Infra-red or radiant gas heaters installed in high bays.
18. Night setback/setup thermostats.

19. Thermostatically-controlled radiator/convector valves.
20. Modify heating controls
21. Install dry bulb economizer controls.
22. Reduce air flow.
23. Prevent air stratification.
24. Install time clocks.
25. Chiller replacement.
26. Chiller controls.
27. Revise or repair building HVAC controls.
28. Waste heat recovery.
29. Install steam booster heaters to raise hot water temperature for dishwashing.
30. Install summer boiler for domestic hot water.

* When analyzing lighting ECOs be sure to consider adequate lighting levels, color rendition, and distribution.

ANNEX B

DETAILED SCOPE OF WORK

ENERGY SAVINGS OPPORTUNITY STUDY

WHITE SANDS MISSILE RANGE, NM

1. All of the facilities covered by this scope of work are located at White Sands Missile Range (WSMR), NM. The majority of the facilities are located on the main post, which is approximately 45 miles north of El Paso, Texas. Some four or five buildings in the study are approximately five miles distant from the main post. For reasons of safety and security, access to some facilities is controlled. Temporary passes will be required for these areas and escorts will be required for some.

2. The AE shall provide all necessary efforts, services, and materials required to accomplish the work specified.

3. Mr. Julian Delgado shall be the installation representative for this study.

4. The work in this annex is grouped under four headings, General Energy Conservation Opportunities, Demand-Limiting Measures, Energy Analysis of Existing Buildings, and Energy Surveys of New Buildings.

4.1 General Energy Conservation Opportunities: A list of general energy conservation opportunities (ECOs) is located in Annex A. ECOs from Annex A are to be investigated for specific buildings as indicated by the X's in the matrix provided at the end of this annex.

4.2 Demand-Limiting Measures: Reduction of electrical demand charges is a high priority at WSMR. The AE will:

a. Gather and analyze data on electrical demand at WSMR for the past three fiscal years.

b. Recommend measures for demand limiting, peak shaving, or reduction of overall demand charges.

c. Evaluate the following energy conservation opportunities;

1) Installation of a central chilled water plant with low temperature (ice or chilled water) storage for the Tech Area.

2) Installation of a cogeneration system [gas turbine, steam (including steam-turbine-driven centrifugal chillers), or hot water] for the Tech Area.

4.3 Energy Analysis of Existing Buildings

4.3.1 Building 300:

4.3.1.1 Building 300, Range Control, is a mission-essential facility. It has high equipment and lighting loads, parts of the building are continuously occupied, and 100 per cent redundancy in chilling capacity has been mandated. Since the building was constructed, however, there have been changes in technology and occupancy which have undoubtedly altered the HVAC load. The AE will gather data on and analyze the existing HVAC system for possible ECOs including but not limited to the following:

a. Consolidate multiple air-cooled chillers into one or two high-efficiency, water-cooled, centrifugal chillers.

b. Revise constant volume air handling systems to variable air volume.

c. Use of low temperature energy storage system (ice or chilled water) for peak demand reduction.

d. Reduce outside air quantities if they exceed the requirements of ASHRAE Standard 62-1989.

e. Use of dry-bulb economizers.

f. Use of waste heat recovery

g. Reduce lighting levels.

h. Use more efficient lighting fixtures.

4.3.1.2 In the investigation of Building 300, the AE is encouraged to make use of field data from the previously completed EEAP study as much as possible; but a thorough site investigation is considered essential. Actual quantities of air or water flow in main ducts or circuits should be determined, but balancing of the system is not required.

4.3.2 Launch Complex 38: Determine technical and economic feasibility of refurbishing centrifugal chillers and cooling towers at Building 24066 for use in central cooling at Launch Complex 38 of Buildings 24072, 23638, 23640, and 23642. Existing systems could be refurbished for backup or supplemental cooling.

4.4 Energy Surveys of New Buildings: The following buildings have not been previously audited. Each shall receive a complete energy audit and shall be considered for all of the applicable ECOs of Annex A.

4.4.1 Building P21140, Temperature Test Facility

4.4.2 Building P21695, SWAB

4.4.3 Building P24072, Helicopter Drone Maintenance Facility

5. The time allowed for completion of the study shall be one calendar year from the date of notice to proceed. The dates for the milestones listed in Annex D shall be agreed upon during the negotiation period.

6. The AE will not bill the district for submittals until review of the particular submittal has been made. Annex D sets the maximum payment allowed for certain phases of completion.

7. The following information shall be made available to the AE for his use in accomplishing this study:

a. Final report and field data for Energy Engineering Analysis Program, White Sands Missile Range, New Mexico, Contract No. DACA63-81-C-0104, dated August 1984. A copy of the report will be provided to the AE. The field data will be available for review and reproduction in the DEH office at WSMR.

b. As-built drawings of WSMR facilities being studied. The AE is responsible for furnishing blue-line paper and the labor required to search for and reproduce any plans needed for this study. The DEH will make the blue-line machine available for use by the AE.

c. ETL 1110-3-254, Use of Electric Power for Comfort Space Heating

d. Architectural and Engineering Instructions.

e. Energy Conservation Investment Program (ECIP) Guidance, dated 25 April 1988 and the latest revision with current energy prices and discount factors for life cycle cost analysis.

f. TM 5-785, 1 Jul 78, Engineering Weather Data

g. TM 5-800-2, 1 Jun 85, Cost Estimates, Military Construction

h. TM 5-815-3, Sep 90, HVAC Control Systems (Draft)

i. AR 5-4, Change No. 1, Department of the Army Productivity Improvement Program.

j. AR 11-27, 13 Aug 89, Army Energy Program

8. The following computer programs will be acceptable for use in building and HVAC system simulation. If it is desired to use a program other than one of the following, it must be submitted for approval as outlined in par 2.7 of the general scope of work.

- a. Building Loads and System Thermodynamics (BLAST)
- b. Carrier E20 or Hourly Analysis Program (HAP)
- c. DOE 2.1B
- d. Trane Air-Conditioning Economics (TRACE)

9. A computer program titled Life Cycle Costing in Design (LCCID) is available from the BLAST Support Office in Urbana, Illinois for a nominal fee. This computer program can be used for performing the economic calculations for ECIP and non-ECIP ECOs. The AE is encouraged to obtain and use this computer program. The BLAST Support Office can be contacted at 144 Mechanical Engineering Building, 1206 West Green Street, Urbana, Illinois 61801. The telephone number is (217) 333-3977 or (800) 842-5278.

10. Reports and correspondence shall be provided in the quantities shown to the offices listed below:

	EXECUTIVE SUMMARY (XS) COMPLETE REPORT, INCL XS	FIELD NOTES	CORRESPONDENCE	
Commander U.S. Army White Sands Missile Range ATTN: STEWS-EL-PE (Delgado) White Sands Missile Range, NM 88002-5076	3	-	1*	1
Commander U S Army Engineer Division, Southwestern ATTN: CESWD-PP-MM (Mr Yacio) 1114 Commerce Street Dallas, TX, 75242 - 0216	1	-	-	-
Commander U. S. Army Engineer District, Fort Worth ATTN: CESWF-ED-MN (Mr Champagne) PO Box 17300 Fort Worth, TX, 76102 - 0300	2	-	1*	1
Commander U S AMC Installation and Service Activity ATTN: AMXEN-B (Mr Badtram) Rock Island, IL, 61299 - 7190	1	-	-	-
Commander U. S. Army Engineer District, Mobile ATTN: CESAM-EN-CC (Mr. Battaglia) PO Box 2288 Mobile, AL 36628-0001	1**	-	-	-
Commander U. S. Army Corps of Engineers ATTN: CEMP-ET (Mr Torabi) 20 Massachusetts Avenue NW Washington, DC, 20314 - 1000	-	1#	-	-
Commander U. S. Army Logistics Evaluation Agency ATTN: LOEA-PL (Mr Keath) New Cumberland Army Depot New Cumberland, PA, 17070 - 5007	-	1#	-	-

- * To be submitted in final form with the interim submittal
- ** Final report after all changes have been incorporated
- # Final Executive Summary after all changes have been incorporated

BUILDING/ECO MATRIX

BUILDING NO. & DESCRIPTION	ECO NO. from ANNEX A											
	2	4	7	9	10	12	13	17	19	20	29	30
P 100 Post HQ				X					X	X		
P 102 Finance Admin				X	X							
T 117 Admin, General	X											
P 124 Admin, Civ Personnel				X	X				X	X		
P 128 EM Barracks				X								
P 129 EM Barracks				X								
P 143 EM Barracks				X								
P 153 Operations Group					X							
P 160 Consolidated Mess			X									
P 236 Gymn					X							X
P 254 Theater					X							
P 260 Post Exchange					X							
P 300 Range Control					X							
P 380 Admin					X							
P 464 Education Building					X							
P 501 Daycare/Trans BOQ				X								
P 502 BOQ Male				X								
P 503 BOQ Male				X								
P 504 BOQ Male				X								
P 1330 Officers' Open Mess											X	
P 1504 Ord Admin					X							
P 1506 Admin ELC					X							
P 1512 Electrical Facil					X							
P 1526 Electrical Facil					X							
P 1528 Laboratory, Genl					X							
P 1530 Admin General		X			X							
S 1550 GM Facility								X				
S 1554 GM Facility								X				
S 1558 Admin General					X							
P 1621 Signal Lab					X							
P 1622 Communication Fac					X							
P 1624 Communication Fac					X							
P 1644 Signal Maintenance								X				
S 1680 GM Facility								X				
P 1743 Gen Warehouse						X	X					
P 1751 FE Maintenance					X	X	X	X				
S 1753 Engr Fld Mnt					X	X	X	X				
P 1782 Trans Cent Admin		X										
P 1788 Motor Shop								X				
S 1790 Ord Fld Mnt					X	X	X					
P 1794 Ord Fld Mnt					X	X	X	X				
P 1827 Gen Warehouse								X				
P 1830 Admin Genl	X	X				X	X					
P 1833 Gen Warehouse								X				
P 1845 Gen Warehouse						X	X					

ANNEX C

EXECUTIVE SUMMARY GUIDELINE

1. Introduction.
2. Building Data (types, numbers, sizes, etc.)
3. Present Energy Consumption.
 - o Total Annual Energy Used.
 - o Site Energy Consumption.
 - Electricity - KWH, Dollars, BTU
 - Fuel Oil - GALS, Dollars, BTU
 - Natural Gas - THERMS, Dollars, BTU
 - Propane - GALS, Dollars, BTU
 - Other - QTY, Dollars, BTU
 - o Energy Consumption of the buildings in this study as compared to the basewide consumption.
4. Historical Energy Consumption.
5. Energy Conservation Analysis.
 - o ECOs Investigated.
 - o ECOs Recommended.
 - o ECOs Rejected. (Provide economics or reasons)
 - o ECIP Projects Developed. (Provide list)*
 - o Non-ECIP Projects Developed. (Provide list)*
 - o Operational or Policy Change Recommendations.

* Include the following data from the life cycle cost analysis summary sheet: the cost (construction plus SIOH), the annual energy savings (type and amount), the annual dollar savings, the SIR, the simple payback period and the analysis date.
6. Energy and Cost Savings.
 - o Total Potential Energy and Cost Savings.
 - o Percentage of Energy Conserved.
 - o Energy Use and Cost Before and After the Energy Conservation Opportunities are Implemented.

ANNEX D

MILESTONES/DATES/PAYMENT SCHEDULE

<u>MILESTONE</u>	<u>APPROX DATE</u>	<u>MAX ALLOWABLE PAYMENT, %</u>
1. Prenegotiation Conference	_____	N/A
2. Negotiation Conference	_____	N/A
3. Notice To Proceed	_____	0
4. Entry Interview	_____	10
5. Exit Interview	_____	20
6. Interim Submittal	_____	20
7. Interim Presentation & Review Conference	_____	50
8. Prefinal Submittal	_____	50
9. Prefinal Presentation & Review Conference	_____	90
10. Final Submittal	_____	100

APPENDIX A

Attached to and a Part of Contract NO. DACA63-91-C-0152

Announcement No. DACA63-90-R-0038

I. SCOPE OF WORK

A. General. The Architect-Engineer (A-E) shall furnish all services, materials, supplies, plant, labor, equipment, investigations, studies, superintendence and travel as required in connection with services for the project identified herein. The work shall be in accordance with the contract, Appendix A, and all furnished instructions.

INSTALLATION

PROJECT TITLE

White Sands Missile Range, NM

Energy Savings Opportunity
Survey (ESOS)

2. The work, submittals, other related data and services required in accordance with this project shall be accomplished within the scope of work described in paragraph 3. The schedule for delivery of data to the Contracting Officer is in calendar days as follows:

	BASIC CONTRACT	DELIVERY SCHEDULE
a. Interim Submittal(s) and Related data for Studies Proceed	*	120 calendar days after Notice to
b. Pre-Final Submittal(s)	*	120 calendar days after approval of Interim submittal
c. Final Submittal (original and All Data Developed under this Contract)	*	120 calendar days after approval of the Pre-Final Submittal

(See Annex "B" for Distribution of Copies)

3. The items of work included in this contract shall be in accordance with criteria furnished at the Scoping Conference held at White Sands Missile Range, 18 and 19 March 1991. The services to be provided shall include, but not be limited to, the following Scope of Work.

a. Items of Work: (See the enclosed Detailed Scope of Work)

b. Government Furnished Items.

- (1) Existing completed energy documents.
- (2) Project Location Map
- (3) As-built drawings as available.
- (4) Existing Planning Documents
- (5) Access to facilities for the as-built work.

c. Special Requirements - distribution of submittal documents:

- (1) Copies of all documents shall be mailed to:

Commander
U.S. Army Engineer District, Fort Worth
819 Taylor Street/P.O. Box 17300
ATTN: CESWF-ED-M/Richard Champagne
Fort Worth, Texas 76102-0300

- (2) Copies of all documents shall be mailed to:

Commander
U.S. Army White Sands Missile Range
ATTN: STEWS-EL-PE/Mr. Delgado
White Sands Missile Range, New Mexico, 88002-5076

(See Annex "B" for distribution of all copies)

CONFIRMATION NOTICE

Confirmation No.001

EMC No.:1110-000

DATE: 3 September 1991
To/From: Tony Battaglia
Representing: C.O.E. Mobile District

PHONE NO.:(205) 690-2618

PROJECT: White Sands Missile Range ESOS Study
CONTRACT NO: DACA63-91-C-0152

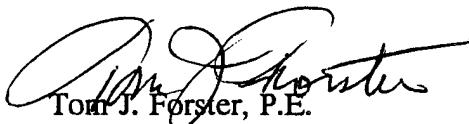
NOTICE
PREPARED BY: T. Forster
EMC Engineers, Inc.

SUBJECT: The Scope of Work

On 3 September 1991 I called Tony to get clarification of the intent of paragraph 7.3 of the detailed SOW, and paragraph 4.3 of Annex B. The building/ECO matrix on page B-6 of the SOW does not include all of the ECOs listed in Annex A, and I was somewhat confused. Tony explained that for the evaluation of general ECO concepts under paragraph 7.3, we need only evaluate in accordance with the matrix. He said that the three buildings listed in paragraph 4.4 of Annex B should receive very thorough evaluations (all applicable ECOs) as these buildings are relatively new and have not been previously studied.

I asked for interpretation of the sentence in paragraph 2.7 of the detailed SOW regarding computer simulations for those buildings for which significant changes to the heating and or cooling systems are to be evaluated. He responded that conversions to VAV, conversions of air handler type (e.g. single zone to multizone) and chiller replacements would be considered significant changes to the controls.

I based my fee proposal on the above general guidance.


Tom J. Forster, P.E.
Project Manager

Action Required:
Copies to: T. Battaglia

If any portion of this confirmation notice is incorrect, please notify us immediately. If correspondence is not received to the contrary within 14 days, it will be assumed that the decisions and conclusions, and status outlined in this confirmation notice is correct.

CONFIRMATION NOTICE

Confirmation No.002

EMC No.:1110-000

DATE: 26 September 1991
To/From: Julian Delgado
Representing: WSMR DEH

PHONE NO.:(505) 678-5415

PROJECT: White Sands Missile Range ESOS Study
CONTRACT NO: DACA63-91-C-0152

NOTICE
PREPARED BY: T. Forster
EMC Engineers, Inc.

SUBJECT: Site investigation coordination.

Julian requested a letter listing the survey team members with SSN, height, weight, color of hair and eyes, and US citizen status about two weeks before the survey starts. He will get badges made in advance. He will send us a base area map showing buildings right away. He requested that I notify him when we get the NTP and have the survey schedule completed.


T. Forster
Project Manager

Action Required:
Copies to:

If any portion of this confirmation notice is incorrect, please notify us immediately. If correspondence is not received to the contrary within 14 days, it will be assumed that the decisions and conclusions, and status outlined in this confirmation notice is correct.

CONFIRMATION NOTICE

Confirmation No.003

EMC No.:1110-000

DATE: 22 October 1991

PHONE NO.:(817) 334-2750

TO: Richard Champagne
CESWF-ED-MP
Fort Worth Engineer District

PROJECT: White Sands Missile Range ESOS Study
CONTRACT NO: DACA63-91-C-0152


NOTICE

PREPARED BY: T. Forster
EMC Engineers, Inc.

SUBJECT: Telephone Conversation on 22 October 1991

Based on our telephone conversation today, I understand the following:

1. ANNEX D of the S.O.W. in the contract contains no dates. Milestones will be as shown on the attached ANNEX D chart.
2. Invoices will be submitted monthly along with a project progress report showing the percent complete. Retainage is to be 10%.
3. The addendum to the S.O.W. provided by Huntsville on 16 September does not apply to the contract.


T. Forster, P.E.
Project Manager

Action Required:
Copies to:

If any portion of this confirmation notice is incorrect, please notify us immediately. If correspondence is not received to the contrary within 14 days, it will be assumed that the decisions and conclusions, and status outlined in this confirmation notice is correct.

10/21/91

TJF.

ANNEX D

MILESTONES/DATES/PAYMENT SCHEDULE

<u>MILESTONE</u>	<u>APPROX DATE</u>	<u>MAX ALLOWABLE PAYMENT. %</u>	<u>*</u>
1. Prenegotiation Conference	_____	N/A	
2. Negotiation Conference	_____	N/A	
3. Notice To Proceed	<u>10/21/91</u>	0	
4. Entry Interview	<u>10/29/91</u>	10	
5. Exit Interview	<u>11/20/91</u>	20	
6. Interim Submittal	<u>4/18/91</u>	20	
7. Interim Presentation & Review Conference	<u>open</u>	50	
8. Prefinal Submittal	<u>+ 60 days</u>	50	
9. Prefinal Presentation & Review Conference	<u>open</u>	90	
10. Final Submittal	<u>+ 21 days</u>	100	

* Invoice monthly based
on % complete.

CONFIRMATION NOTICE

Confirmation No.005

EMC No.:1110-000

DATE: 18 November 1991

PROJECT: White Sands Missile Range ESOS Study
CONTRACT NO: DACA63-91-C-0152

NOTES

PREPARED BY: T.Forster
EMC Engineers, Inc.

DATE OF
CONFERENCE: 29 October 1991

PLACE OF
CONFERENCE: Bldg 1768, DEHL/WSMR, NM

SUBJECT: Entry Interview

ATTENDEES: Donald Ziegenfuss/ DEHL(EL-P) 505 678-2236
Julian Delgado/STEWS-EL-PE 505 678-5415
Tom Forster/ EMC Engineers, Inc. 303-988-2951
Alan Niemeyer/EMC Engineers, Inc. 303-988-2951
Angela Stover/EMC Engineers, Inc. "

T. Forster introduced the survey team members and briefly reviewed the survey requirements for the four elements of the Scope of Work. General survey procedures were described, and support requirements were presented. The general project plan was reviewed, and a tentative survey schedule was presented. A copy of the Entry Interview was distributed to each attendee, and is incorporated into these minutes by attachment.

J. Delgado reviewed the security and escort procedures and requirements relating to our survey, and provided keys to the mechanical rooms and to Building 364, which served as a field office for the team.



Tom J. Forster, P.E.
Project Manager

Attachment: Entry Interview

cc: Richard Champagne, CESWF-ED-MP, Ft. Worth C.O.E.
J. Delgado, WSMR/ STEWS-EL-PE

CONFIRMATION NOTICE

Confirmation No.006

EMC No.:1110-000

DATE: 18 November 1991

PROJECT: White Sands Missile Range ESOS Study

CONTRACT NO: DACA63-91-C-0152

NOTES

PREPARED BY: T. Forster
EMC Engineers, Inc.

DATE OF
CONFERENCE: 14 November 1991

PLACE OF
CONFERENCE: Bldg 1768, DEHL/WSMR, NM

SUBJECT: Exit Interview

ATTENDEES: Manuel Amaro/Acting DEHL(EL-P) 505 678-1581
Julian Delgado/STEWs-EL-PE 505 678-5415
Edward Manzanares/STEWs-EL-EM 505 678-4286
Gerry Arvizo/STEWs-EL-PE 505 678-5974
Tom Forster/ EMC Engineers, Inc. 303-988-2951

T. Forster reported on the results of the field survey efforts of the EMC team. The survey began with the Entry Interview on 29 October, with D. Ziegenfuss and J. Delgado in attendance. The survey was completed on 14 November 1991.

- The 45 buildings shown in the Annex B matrix (pg B-6) were surveyed for the specified Energy Conservation Opportunities (ECOs). All required data was obtained.
- Electric demand billing and meter data were received from J. Delgado to support an analysis of the post electric demand and to determine ways of reducing and controlling the demand. Based on the observations made during the building surveys, the following ways appear to have some merit in reducing demand:
 - a. Reduce air flow rates in some buildings and downsize fan motors.
 - b. Replace old, inefficient fluorescent lighting systems throughout the post with low wattage lamps and ballasts.
 - c. Install thermal storage (to be evaluated).
 - d. Install cogeneration (to be evaluated).
 - e. Consolidate chilled water loads onto central plants at Bldg 300 and in the Tech Area (to be evaluated).
 - f. Install a SCADA type electric utility control system.

g. Resize and replace electric motors with high efficiency motors.

- Building 300: The survey is complete except for equipment heat gains, which will be sent to EMC by STEWS-EL-PE by 9 January 92. Our observations include:
 - a. The building HVAC systems are operated manually. Controls have been disconnected.
 - b. There is considerable potential to reduce overall air flow rates and electric motor power draw by installing variable speed controls on the AHUs, and capping selected supply air registers.
 - c. There appears to be potential for a consolidated chilled water plant with heat recovery off the chillers.
 - d. Dry bulb economizers exist, but the controls are not in use. It appears that considerable improvement in temperature control and reduced energy consumption may result with the restoration of the economizer controls.
 - e. A general lighting reduction program has been in place for several years, but new, high efficiency lighting appears to offer additional savings.
- Launch Complex 38: Refurbishment of the central chilled water plant in P-24066 is not feasible because of severe deterioration of the chillers, cooling tower, chilled water and condenser water piping. The system was abandoned in 1965 and was not drained or mothballed, and the deterioration is extensive. Also, new chillers are on order for 23640 and 23642, and will be more efficient than the 1959 chillers in 24066, and easier to maintain.
- Building P-24072: This building houses the helicopter drone maintenance activity, which has been reduced in scope in recent years. The building is not suitable for such activity, and to modify it would be extremely expensive. The drone maintenance activity should be relocated.
- Building P-21695: This building is a candidate for several ECOs: new windows, insulated pipes, and modified air distribution for the offices and high bays.
- Building P-21140: The nontest use of energy in this building is minuscule, and there are no ECOs that apply to the building.
- TECH AREA: Potential exists in the TECH AREA for a central chilled water plant and for cogeneration. These will be evaluated. The building tenants are very concerned about reliability of their chilled water supplies, and are generally not aware of the condition of the existing chillers and air-cooled condensers and cooling towers.

Contractor-Identified ECOs: The following ECOs were identified and appear to have merit in reducing energy consumption and in reducing electrical demand at WSMR:

Building P-23640:

1. Replace the standard fluorescent lighting system with a low wattage

- system.
2. Reduce the supply air flow rate on the main AHU and replace the fan motor.
 3. Restore the comfort AHU to full operation with economizer and cooling coil.
 4. Optimize the control of the cooling coils in both AHUs.

Building P-23642:


1. Replace the standard fluorescent lighting systems in the west wing and main vault with low wattage systems.
2. Reduce the supply air flow rate and replace the fan motors on the two AHUs that serve the west wing.
3. Reduce the supply air flow rate on the main air handler that supplies the vault and replace the fan motor.
4. Optimize the control of the cooling coils in all AHUs.

Building P-300:

1. Replace all supply and return air fan motors with high efficiency motors.
2. Optimize control of the heating and cooling coils on all AHUs.
3. Install time clocks to control operation of the comfort AHUs.

Replace main AHU fan motors with high efficiency motors in the following buildings:

P-1506	P-1512	P-1526	P-1528
P-1530	P-1621	P-1622	P-1624


Tom J. Forster, P.E.
Project Manager

cc: Richard Champagne, CESWF-ED-MP, Ft. Worth C.O.E.
J. Delgado, WSMR/ STEWS-EL-PE
M. Amaro, WSMR/DEHL (EL-P)
E. Manzanares, WSMR/STEWs-EL-EM
G. Arvizo, WSMR/STEWs-EL-PE

Action Required:
Copies to:

If any portion of this confirmation notice is incorrect, please notify us immediately. If correspondence is not received to the contrary within 14 days, it will be assumed that the decisions and conclusions, and status outlined in this confirmation notice are correct.

CONFIRMATION NOTICE

Confirmation No. 007

EMC No.:1110-000

DATE: 10 January 1992

PROJECT: White Sands Missile Range ESOS Study
To: R. Champagne (817) 334-2750
From: Tom Forster

CONTRACT NO: DACA63-91-C-0152

NOTES
PREPARED BY: T. Forster
EMC Engineers, Inc.

DATE OF
CONFERENCE: 10 January 1992

PLACE OF
CONFERENCE: Telephone Call


SUBJECT: Contractor-Identified ECOs

ATTENDEES:

It was agreed that the contractor-identified ECOs described on pages 2 and 3 of Confirmation Notice 006 dated 18 Nov. 91 for buildings 23640 and 23642 will be treated as single ECOs. That is, a baseline energy consumption for each building will first be established by computer simulation, then an energy consumption level for the ECO package will be established for each building.

It was agreed that work in evaluating the contractor-identified ECOs replaces the work to evaluate refurbishment of the centralized chiller plant in 24066 without additional contractor fee.

I stated that at this point I think we can maintain the same project schedule.


Tom J. Forster, P.E.
Project Manager

cc: Richard Champagne, CESWF-ED-MP, Ft. Worth C.O.E.

Action Required:
Copies to:

If any portion of this confirmation notice is incorrect, please notify us immediately. If correspondence is not received to the contrary within 14 days, it will be assumed that the decisions and conclusions, and status outlined in this confirmation notice are correct.

CONFIRMATION NOTICE

Confirmation No. 008

EMC No. 1110-000

DATE: 3 June 1992

PROJECT: White Sands Missile Range ESOS Study
CONTRACT NO: DACA63-91-C-0152

NOTES

PREPARED BY: T. Forster
EMC Engineers, Inc.

DATE OF
CONFERENCE: 28 May 1992

PLACE OF
CONFERENCE: Bldg 1768, DEHL/WSMR, NM

SUBJECT: Interim Report Presentation and Review.

ATTENDEES: Anthony Battaglia/EEAP TCX
Mobile District, C.O.E. - 205-690-2618

Richard Champagne/CESWF-ED-MP
Fort Worth District, C.O.E.

Julian Delgado/STEWS-EL-PE
WSMR/DEHL - 505 678-5415

Tom Forster/ EMC Engineers, Inc. - 303-988-2951
Project Manager

Alan Niemeyer/EMC Engineers, Inc. - 303-988-2951
Engineer In Charge

T. Forster formally reviewed the interim report section by section. The general nature of the Main Post electrical demand profiles were noted, and the general recommendations for reducing and shifting demand were also reviewed. T. Forster recommended that a feasibility study for the installation of an EMCS at WSMR be conducted as soon as funds are available. It was agreed that the recommendation should appear in the prefinal report.

The Main Post demand profile was discussed, and the general recommendations for reducing and shifting demand were reviewed.

The general ECO evaluation results were discussed, and it was noted that heated buildings have only approximately 1000 annual heating degree days at the WSMR because of the effects of internal heat gains from lights, occupants and processes. Heating of many buildings only occurs at outdoor temperatures of 45 deg F and below when occupied. In general this defeats the

economic effectiveness of ECOs that address natural gas savings. The heating loads are not great enough to pay for ECO retrofits. Five general ECOs will receive additional effort in the prefinal phase:

- ECO 10: Electric Point of Use Water Heaters. The required number of heaters per building will be rechecked, and the LCCAs will be reaccomplished for the new natural gas price and an electrical energy price of \$0.0221/Kwh.
- ECO 13: Replace standard fluorescent lighting equipment with new, efficient equipment. EMC will analyze the application of the rare earth phosphor lamps and high frequency, electronic ballasts to two buildings to determine the general applicability. T. Forster will notify J. Delgado of the results by letter.
- ECO 17: Replace Unit Heaters with IR Heaters. The construction cost estimates for this ECO will be rechecked, and the results revised as necessary.
- ECOs 19 and 20: Thermostatic Control Valves and Modified Heating Controls. The ECO concept application will be checked for validity for P100 and P124. Any necessary corrections will appear in the prefinal report, and will be reported to J. Delgado, T. Battaglia and R. Champagne by letter.
- ECO 9: Replace Windows. Building P501 will be reported as the portion that is identical to P502. The rest of the building will be omitted from the analysis. This will greatly increase the effectiveness of replacing windows in P501.

T. Forster noted that the interim report analysis of dry bulb economizers for P300 is incorrect. It was necessary to simulate the two air handlers in each wing of the building as a single AHU. This caused the trace program to calculate excessive hot deck heating loads. This will be corrected in the prefinal report.

J. Delgado questioned the sequencing of chillers in the baseline simulation of P300. It was agreed to meet with Comfort Zone Inc. technicians to clarify the matter.

It was noted that the package of ECOs for P300 will qualify for the ECIP program. T. Battaglia was not aware that other funds are available, and that ECIP offers the best chance for implementation. It was agreed that under the ESOS study contract, EMC is responsible for providing calculations and backup data for inclusion in the ECIP Project Development Brochure. J. Delgado said that he and his staff are trained and able to develop the DD1391 and PDB, but that he would prefer EMC do it if possible. This request was left open. T. Battaglia stated that the latest ECIP guidelines require a minimum project investment cost of \$300,000 rather than \$200,000. T. Forster requested that R. Champagne send EMC the latest ECIP guidelines.

For P24072 it was noted that the existing main building transformer is much larger than necessary, and that the secondary voltage is reported to fluctuate and rise to 525 volts at times. This has a very adverse effect on the operation of the fluorescent lights. It was agreed that this would be reported in the prefinal report, but that the cost of replacing or repairing the transformer would not be included in the lighting ECO.

For the consolidated chiller plant ECO in LC 38, it was agreed that the synergistic effects of upgrading the buildings as per EMC's recommendations would be determined, and that the plant capacity would be revised as needed.

It was agreed that the chiller plant for the Tech Area would not be pursued any further in the prefinal phase. It simply is not economically feasible.

T. Forster recommended that in the prefinal report, Appendix C be designated for program documentation, and that Appendix D contain the calculations and backup data. This was agreed to by all parties. It was also agreed that the Volume I, Book 1 binders would be retained for the prefinal and final reports. EMC will provide inserts and instructions. Vol. II, Building Survey Forms binders will be retained, and EMC will reissue the entire contents. The printing of the forms in the interim report was unsatisfactory.

It was agreed that all ECOs that qualified with SIR of 1.0 or greater in the interim phase would be reevaluated with the new natural gas price. This will reduce the SIRs and increase the SPBs.

ACTION ITEM SUMMARY:

1. EMC will provide J. Delgado the results of reevaluations of ECO 10, and the viability of using rare earth phosphor lamps with high frequency, electronic ballasts as replacement for existing fluorescent equipment.
2. EMC will recheck the construction cost of installing IR heaters in the designated buildings and reevaluate the LCCAs if required. He will notify J. Delgado of the results by letter.
3. EMC will reanalyze the application of dry bulb economizers on P300.
4. EMC will verify the correct sequence of chiller operation for P300.
5. Richard Champagne will provide EMC with the latest version of ECIP program guidance.
6. J. Delgado will provide EMC with the latest natural gas price, and with U. S. Department of Labor construction wage rates for New Mexico.

Tom J. Forster, P.E. *TJF*
Project Manager

cc: Richard Champagne, CESWF-ED-MP, Ft. Worth C.O.E.
J. Delgado, STEWS-EL-PE, WSMR
A. Battaglia, EEAP TCX, Mobile C.O.E.

CONFIRMATION NOTICE

Confirmation No. 009

EMC No. 1110-000

DATE: 3 June 1992

PROJECT: White Sands Missile Range ESOS Study

CONTRACT NO: DACA63-91-C-0152

NOTES

PREPARED BY: T. Forster
EMC Engineers, Inc.

DATE OF
CONFERENCE: 29 May 1992

PLACE OF
CONFERENCE: Bldg. 1768, DEHL/WSMR, NM

SUBJECT: Prefinal Phase Planning Meeting.

ATTENDEES: Anthony Battaglia/EEAP TCX
Mobile District, C.O.E. - 205-690-2618

Julian Delgado/STEWS-EL-PE
WSMR/DEHL - 505-678-5415

Tom Forster/ EMC Engineers, Inc. - 303-988-2951
Project Manager

Alan Niemeyer/EMC Engineers, Inc. - 303-988-2951
Engineer In Charge

T. Forster reconfirmed that all ECOs that qualified in the interim report for implementation will be reevaluated for the new natural gas price. This will reduce the SIR and increase the SPB.

The attendees visited LC-38 and toured buildings P24072 and P23642. A windshield tour of the complex was made, and it was noted two new chilled water cold generators have been installed at P23640. This effectively nullifies the implementation of Alternative 2B for LC 38. It was also noted that P23642 requires immediate retrofitting in order to meet mission requirements. In view of these developments, and that a work order has been submitted to install 2 new cold generators at P23638, it was agreed that the consolidated chiller plant ECO for LC 38 be abandoned, and no additional analysis or effort be expended.

The group inspected the heating systems in P100 and P124. P100 is equipped with low pressure steam finned tube radiators with self-contained thermostatic control valves. Overheating of spaces is still a problem. P124 is equipped with a hot water baseboard heating system. The boiler is equipped with an outdoor thermostat that actuates the boiler controls at 58 deg F. Supply water temperature is controlled by a manual setpoint control on the boiler and was set for 130 deg F.

Forster confirmed that ECOs 19 and 20 will be reevaluated to reflect the actual mechanical equipment installed.

S1530 was inspected to determine the application of lowering ceilings in offices. It was agreed that lowering ceilings have no practical energy saving application to this building, and that the interim report results will stand.

J. Delgado instructed EMC to use 1 October 1996 as the beginning of construction for ECIP projects.

It was agreed that in lieu of preparing program documentation for the projects in LC 38, EMC will prepare a suggested scope of work to be used in contracting the retrofitting of the buildings. It was recommended that the consolidated chiller plant for LC 38 not be pursued any further. The prefinal report will document the reason for this.

ACTION ITEM SUMMARY:

1. EMC will provide J. Delgado the results of reevaluations of ECO 10, and the viability of using rare earth phosphor lamps with high frequency, electronic ballasts as replacement for existing fluorescent equipment.
2. EMC will recheck the construction cost of installing IR heaters in the designated buildings and reevaluate the LCCAs if required. He will notify J. Delgado of the results by letter.
3. EMC will reanalyze the application of dry bulb economizers on P300.
4. EMC will verify the correct sequence of chiller operation for P300.
5. Richard Champagne will provide EMC with the latest version of ECIP program guidance.
6. J. Delgado will provide EMC with the latest natural gas price, and with U. S. Department of Labor construction wage rates for New Mexico.

Tom J. Forster, P.E. ~~ASW~~
Project Manager

cc: Richard Champagne/CESWF-ED-MP, Ft. Worth C.O.E.
J. Delgado/STEWS-EL-PE, WSMR
A. Battaglia/EEAP TCX, Mobile C.O.E.

07 October 1992

EMC #1110-000

US Army Engineer District, Fort Worth
ATTN: Richard Champagne/CESWF-ED-MP
P.O. Box 17300
Fort Worth Texas 76102-0300

Re: Responses to Reviewers' Comments on the Prefinal Report, White Sands Missile Range ESOS Study: Contract No. DACA63-91-C-0152

Dear Richard:

On 28 September 92 EMC received reviewers' comments from A. Battaglia, J. Delgado and Clay Thompson via FAX from you. Our responses to the comments are shown below. I have reviewed our responses to Tony's comments with him, and intend to contact Julian Delgado by telephone as soon as he has a telephone line installed in his new office.

A. Battaglia

We concur with all of Mr. Battaglia's comments. The final report will incorporate all necessary changes to address his comments.

J. Delgado

We concur with all comments except Nos. 9, 10, 19 and 23. Our responses to these exceptions are shown below. All other comments will be addressed in the final report.

No. 9. The use of existing gas-fired domestic water heaters in the designated buildings was modeled to include the energy of water used by building occupants and processes, and for all system losses: storage loss, piping loss and gas combustion loss (heater efficiency). The electric energy of circulation pumps was also included. The analysis shows in every case that the gas cost savings achieved by installing point of use electric heaters is not sufficient to pay for the increase in electric energy costs and the considerable cost of installing the electric heaters. Gas is so cheap at the WSMR that conversion of gas loads to electricity are just not cost effective at today's energy prices.

No. 10. We agree that for some installations the latest reflector technology has cost effective application. However, at the WSMR lighting energy conservation is already practiced to a high degree, so that illumination levels are already reduced to the minimum acceptable level in most

buildings. In this situation, equipping existing fixtures with reflectors and removing additional lamps will reduce illumination to unsatisfactory levels. The effective use of reflectors in the designated buildings will require that existing fixtures be moved to make room for additional fixtures in order to preserve adequate illumination. The implementation cost is relatively high and the energy savings relatively low. Our company experience on other energy projects at government facilities confirms the above comments. The addition of reflectors to existing fixtures without respacing the fixtures and increasing the number of fixtures invariably results in inadequate lighting, and the reflectors are subsequently removed and lamps reinstalled by maintenance personnel.

No. 19 We agree that if an electric load is shifted from the day peak demand period to the off peak period, peak demand is reduced and dollars are saved. If the equipment then operates for the same number of hours off peak as it did on peak, no energy is saved, and no energy dollars are saved. The discussion of this on page 8-8 is intended to clearly present this conclusion. If it is not clear in its present form, please advise and we will change it to clarify it.

No. 23 The use of \$18.37/Mbtu in part 2 of the LCCA summary sheets for the ECOs in question is correct if the ECO concept results in reduced electric energy without reduction in peak demand. If the ECO results in both energy and demand savings, \$6.48/Mbtu is used in part 2 and \$19.50/Kw is used in part 3. This approach results in the maximum ECO cost savings and is in compliance with current ECIP guidance. In our opinion, the selected energy unit prices are correct for each of the ECOs, and changing them will result in lowering the SIRs.

C Thompson

We were unaware that the ECIP guidance was changed in June to eliminate the 25% maximum nonenergy savings restriction. Unfortunately, we were not informed about the change, which could have easily been incorporated into the prefinal analyses. At this point it is a significant amount of work to make the changes, which requires the recalculating the Life Cycle Cost and SIR for many buildings, changing most of the economic summary tables in the report, and changing some recommendations. This would seem to be outside the contract effort, and perhaps should be performed under a modification to the contract.

Please contact me if you have questions or need further clarification.

Very truly yours,

E M C Engineers, Inc.

Tom J. Forster, P.E., Ph.D
Project Manager

FACSIMILE TRANSMITTAL HEADER SHEET

For use of this form, see AR 25-11; the procuring agency is ODISC4

COMMAND/ OFFICE	NAME/ OFFICE SYMBOL	OFFICE TELEPHONE NO. (AUTOVON/Comm.)	FAX NO. (AUTOVON/Comm.)			
US ARMY C.O.E	RICHARD CHAMPAGNE CESNF-ED-MP.	(817) 334-2750	(817) 334-4341			
TO: EMC ENGRS. INC.	TOM FORSTER	(303) 988-2951	(303) 985-2527			
CLASSIFICATION	PRECEDENCE	NO. PAGES (including this Header)	DATE-TIME	MONTH	YEAR	RELEASER'S SIGNATURE
UNCLAS	—	10	28 SEP '92	SEP.	'92	Richard M. Champagne

REMARKS

ESOS COMMENTS ON THE PRE-FINAL SUBMITAL.
THANKS, R.C.

Space Below For Communications Center Use Only

RM 3918-R, JUL 90

DA FORM 3918-R, AUG 72 IS OBSOLETE

FAXED
11/1/900

1 Sep 92

MEMORANDUM THRU CESWF-ED-DE

CESWF-ED-DM

1. Subject project is being accomplished by E.M.C. ENGINEERS, Inc., Denver, Colorado (Project Manager Richard Champagne, ext 4-2750).

a. Vol 1 - Book 1

b. Vol 1 - Book 2

c. Executive Summary

3. ADP Cost Code: ~~9876543210~~
for review.

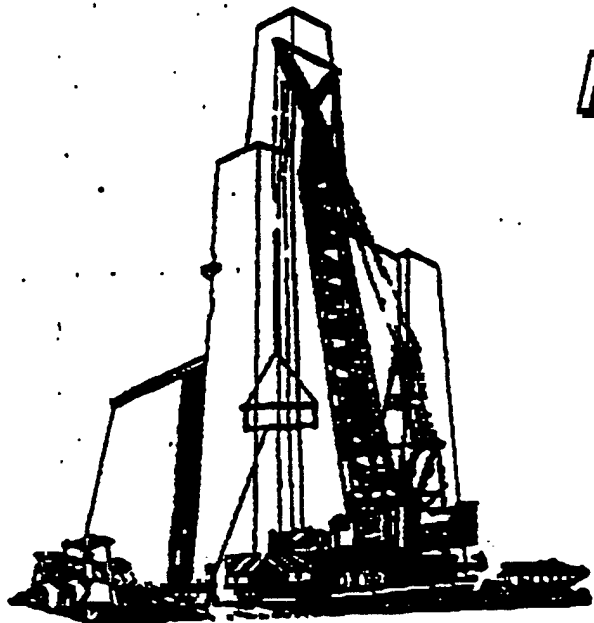
4. ~~Border check and reports changed to this date be submitted with comments on 12/5/99.~~

RICHARD CHAMPAGNE, ALA
Master Planner,
CESWF-ED-MP

* FORT WORTH DISTRICT: NO COMMENTS ON THE PREFINAL SUBMITTAL.

K. Clarys 25 Sep '92

An AMC I & SA Facsimile Transmission



ROCK SOLID FAX

from:

CONSTRUCTION ENGINEERING DIVISION

MR. RICHARD CHAMPAGNE

Office Symbol: _____

Fax Number: 817-334-~~2750~~ 4341

Addressee's Phone Number: FT. WORTH DISTRICT COE
817-334-2750

Number of Pages (Excluding this Cover Page): 0

SUBJECT: BSOS - WSMR

Remarks: COMMENT: THE NON-ENERGY TEST FOR ECIP PROJECTS WAS
ELIMINATED FROM LCCA BEGINNING WITH FY95 ECIP SUBMITTAL GUIDANCE.
ECOs WHICH FAILED THE "TEST" MAY WANT TO BE RECONSIDERED (e.g. ECO 12413)

claythompson



USAMC INSTALLATIONS AND SERVICES ACTIVITY
ATTN: AMXEN-C/MR. CLAY THOMPSON
ROCK ISLAND, IL 61299-7190
COMMERCIAL: (309) 782-5743
AUTOVON: 793-5743
FACSIMILE: (309) 782-7566; DSN 793-7566

A-4

REVIEW COMMENTS		AGENCY		U.S. ARMY		DATE		15 SEP 92		ACTION	
<input type="checkbox"/> CIVIL	<input checked="" type="checkbox"/> MECH	<input type="checkbox"/> FM & S	<input type="checkbox"/> P. S.	<input type="checkbox"/> CONFERENCE							
<input type="checkbox"/> VACH	<input checked="" type="checkbox"/> ELEC	<input type="checkbox"/> EST	<input type="checkbox"/> CONCEPT	<input type="checkbox"/> PRELIMINARY							
<input type="checkbox"/> TRUC	<input checked="" type="checkbox"/> ENERGY	<input type="checkbox"/> FINAL	<input checked="" type="checkbox"/> PRE-FINAL								
PROJECT				LOCATION							
ENERGY SAVINGS OPPORTUNITY SURVEY (ESOS)				WSMR							
CMT. NO.	DWG. NO. OR REF.	REVIEWER				PHONE				ACTION BY	
		JULIAN T. DELGADO				(505) 678-5415					
VOLUME 1, BOOK 1											
1	Pg ES-1	Add, "for WSMR Lower Range" after title "Recent Historical Energy Consumption"									
2	Pg ES-8	TABLE ES-6: Why did Elec. Demand go down from Interim Report?									
3	Pg ES-12	TYPO: third line from top of page.									
4	Pg ES-13	Rewrite first and second sentences to read, "The average El Paso Electric Company peak KW for WSMR is 18,150 KW, and is referred to as the conjunctive peak. It is the sum of KW demand readings recorded at each of the six substations corresponding to the date and time of the highest monthly demand registered; usually the peak demand occurs at the time the Main Post substation peaks."									
5	Pg ES-14	Typo: Change Table ES-12 to ES-11 on second to last sentence.									
6	Pg 2-1	Add, "FOR WSMR LOWER RANGE" after title, "HISTORICAL ENERGY CONSUMPTION"									
7	Pg 2-2	Remove "Utility" from first sentence. Insert the word "usually" between the words "demand determines" and replace the words, "WSMR as a whole" with "Lower Range" in second sentence. Remove third sentence entirely and replace with second sentence of CMT. No. 4 above, "It is the sum...peaks."									
8	Pg 3-7	ECO #9 Conclusion is valid; however, reducing the amount of windows may have been a better option.									
9	Pg 3-7	Still not convinced this is not an energy saver especially in bldgs that use hot water circulating pumps.									

REVIEW COMMENTS		AGENCY U.S. ARMY		DATE 15 SEP 92		ACTION A - CONCUR D - DO NOT CONCUR E - EXCEPTION X - DELETE (EXPLAIN D, E & X) ACTION BY
<input type="checkbox"/> CIVIL	<input checked="" type="checkbox"/> MECH	<input type="checkbox"/> FM & S	<input type="checkbox"/> P. S.	<input type="checkbox"/> CONFERENCE		
<input type="checkbox"/> ARCH	<input checked="" type="checkbox"/> ELEC	<input type="checkbox"/> EST	<input type="checkbox"/> CONCEPT	<input type="checkbox"/> PRELIMINARY		
<input type="checkbox"/> STRUC	<input checked="" type="checkbox"/> ENERGY		<input type="checkbox"/> FINAL	<input checked="" type="checkbox"/> PRE-FINAL		
PROJECT ENERGY SAVINGS OPPORTUNITY SURVEY (ESOS)			LOCATION WSMR			
CMT. NO.	DWG. NO. OR REF.	REVIEWER JULIAN T. DELGADO			PHONE (505) 678-5415	
10	Pg 3-10	Para. 4: According to El Paso Electric Company technical advisor on lighting, the reflector technology is a good way to go on new fixture applications.				
11	Pg 3-15	Typo: third para, second sentence "valvo".				
12	Pg 3-16	TABLE 3-15: How can baseline, ECO and other analysis be the same for Bldg 124 when Interior Report was based on steam and now narrative is corrected to indicate Bldg 124 has a hot water heating system? Steam heating requires more energy.				
	Pg 3-17	For information only: Boiler in Bldg 236 was replaced by High-Efficiency Boilers this summer.				
14	Pg 4-9	TABLE 4-7: Disagree with the 14.8 KW reduction amount. The basic and most fundamental benefit of Thermal Energy Storage is to shutdown the cooling equipment; in this case at least 200 tons which can be roughly equated to 200 KW's. The Interior Report indicated a total of 2,030.7 KW's with a one-time rebate of \$32,110. Volume 1, Book 2, pg D11-1 does not indicate the rebate amount nor dollar savings to reflect the 2,030.7 KW's. It is difficult to accept that at \$19.50 a KW and energy cost at \$0.0221 per KWH, Thermal Energy Storage is not "economically effective."				
15	Pg 8-3	Same as CMT. No. 6 after title, "HISTORICAL ELECTRICAL DEMAND DATA"				
16	Pg 8-3	Add the following before first para, "El Paso Electric Company provides approximately 94% of WSMR's total electric power."				

REVIEW COMMENTS		AGENCY U.S. ARMY		DATE 15 SEP 92		ACTION	
<input type="checkbox"/> CIVIL	<input checked="" type="checkbox"/> MECH	<input type="checkbox"/> FM & S	<input type="checkbox"/> P. D.	<input type="checkbox"/> CONFERENCE	A - CONCUR D - DO NOT CONCUR E - EXCEPTION X - DELETE (EXPLAIN D, E & X) ACTION BY		
<input type="checkbox"/> ARCH	<input checked="" type="checkbox"/> ELEC	<input type="checkbox"/> SST	<input type="checkbox"/> CONCEPT	<input type="checkbox"/> PRELIMINARY			
<input type="checkbox"/> JTRUG	<input checked="" type="checkbox"/> ENERGY	<input type="checkbox"/> FINAL	<input checked="" type="checkbox"/> PRE-FINAL				
PROJECT LOCATION							
ENERGY SAVINGS OPPORTUNITY SURVEY (ESOS)					NSMR		
CMT. NO.	DWG. NO. OR REF.	REVIEWER JULIAN T. DELGADO			PHONE (505) 678-5415		ACTION BY
16	(continued)	This electric service is provided to the Lower Range where the Main Post and Launch Complexes are located.					
17	Pg 8-4	Replace first and second sentence with what is contained in CMT. No. 4.					
18	Pg 8-8	Disagree with conclusion in para 4.: "At the current electric utility unit prices, thermal storage is not cost effective as a retrofit strategy, but might be so in the future." With one of the highest rates in the country thermal storage should be not only economical but a priority strategy.					
19	Pg 8-8	Disagree that load shifting only saves demand, but no energy costs. If a piece of equipment (chiller) is not operated during peak hours, both KW's and KWH's are saved. Granted energy consumption may increase during non-peak hours, but the cost to do so is significantly reduced (\$0.0221/KWH compared to \$19.50/KW + \$0.0221/KWH). This comment applies to the first equation.					
20	Pg 8-9	Explain the makeup of the \$25.98/MBtu in para 3, 5th sentence. Why is this amount ^{not} used in energy dollar saving calculations?					
21	Pg 8-21	Typo: In first sentence change to "page 8-22."					
22	Pg 9-12	See CMT. No. 4.					
VOLUME 1, BOOK 2 APPENDIX D							
General observation: Why do ECO's # 2, 4, 9 and 17 use \$18.37/MBtu in Part 2 of ICCA Summary when calculating ENERGY SAVINGS? I realize these are not electrical energy							

A-45

PAGE 4 OF 4

To: EMC Engineers, Inc

From: (Section) CESAM-EN-CM

(Reviewer) A Battaglia 205-690-2668

Subject: Energy Savings Opportunity Study

Year:

Line Item No.:

Location: White Sands Missile Range, NM

FY-

Type of Action: Prefinal submittal review

ITEM NO.	DRAWING NO. OR PAR. NO.	COMMENTS	REVIEW ACTION
1.	General	Overall this is a very good report. The analysis is practical and well thought out; and the presentation is excellent.	
2.	Pg 1-1	Par 3. Add to the list of ECOs for Bldg P300 "use of waste heat recovery".	
3.	Pg 3-16	The last sentence on the page should continue on the next page, but it does not. Please correct.	
4.	Pg 4-4	Par 4.2.7 mentions evaluation of a centrifugal chiller with double bundle heat recovery; however, Section 4.7 evaluates a reciprocating chiller with desuperheater. Please correct.	
5.	Sec 8	The following comments apply to Section 8 and corresponding calculations in Appendix D:	
6.	a.	The narratives for Alt #1 and Alt #2, pages 8-15 & 8-16, respectively, do not agree with the data presented in Table 8-3 on page 8-20 nor with the results of the calculations in Appendix D. Also, both narratives refer to Table 8-3 as being on page 8-23. Please correct.	
	b.	The first paragraph on page 8-21 has a good discussion of the cooling load profile for the Tech Area. It would have been helpful to have this discussion right after Table 8-1; because Table 8-1 shows a peak cooling load for the Tech area of 875 tons, but all of the alternates call for 550 tons cooling capacity. Also, in Tab 22, pages D22-10 through D22-15, there are Trace 600 printouts which show the load on the chiller plant for typical days. Similar printouts would be helpful in the tabs for the other alternates as backup for the discussion on cooling load profile.	

Project and Location: Energy Savings Opportunity Study
White Sands Missile Range, NM

FY-

Section: CESAM-EN-CM

DRAWING NO.
OR PAR. NO.

REVIEW ACTION

8. c

In the narratives for Alternates 1 thru 4, and in Table 8-3, the savings-to-investment ratio (SIR) and the simple payback period (SPBP) are shown as calculated for the Energy Conservation Investment Program (ECIP). These values are correct for ECIP; but since the projects did not qualify for ECIP, the SIR and SPBP calculated without regard to the non-energy qualification criteria (i.e., Lines 6 & 7 on the LCCA Summary Sheet) should be shown. Please see par 5.2 in the General Scope of Work for the study. This does not imply that additional project documentation should be prepared; that was already decided at the interim review meeting. However, it should be mentioned in the narrative that Alternates 1 & 2 would qualify for MCA funding if WSMR wanted to pursue that approach.

d

The analyses for Alternates 3 & 4 state that there is plenty of waste heat available from the turbine-generator to take care of cooling and heating requirements for the Tech Area. This is clearly the case on an annual basis; but not so clear for peak loads. Page D23-5 states that 4,000 lb/hr of steam at 100 psig would be available from the heat recovery steam generator with 10% being used for plant auxiliaries, leaving 3,600 lb/hr available for operating chillers and/or space heat, domestic hot water, and process heat. From page D23-20, the smaller turbine drive chiller would require 10,814 lb/hr and the larger would require 24,000 lb/hr when operating at capacity. From page D23-16, the absorption chillers would require 3,273 and 7,013 lb/hr when operating at capacity. Similarly, page D23-13 shows predicted peak heating loads for all buildings in the Tech Area; these loads would certainly not be concurrent, but the peak load on the plant would probably exceed 3,600 lb/hr. Please look into this concern and make any corrections necessary in calculations and narrative.

Project and Location: Energy Savings Opportunity Study
White Sands Missile Range, NM

FY-

Section: CESAM-EN-CM

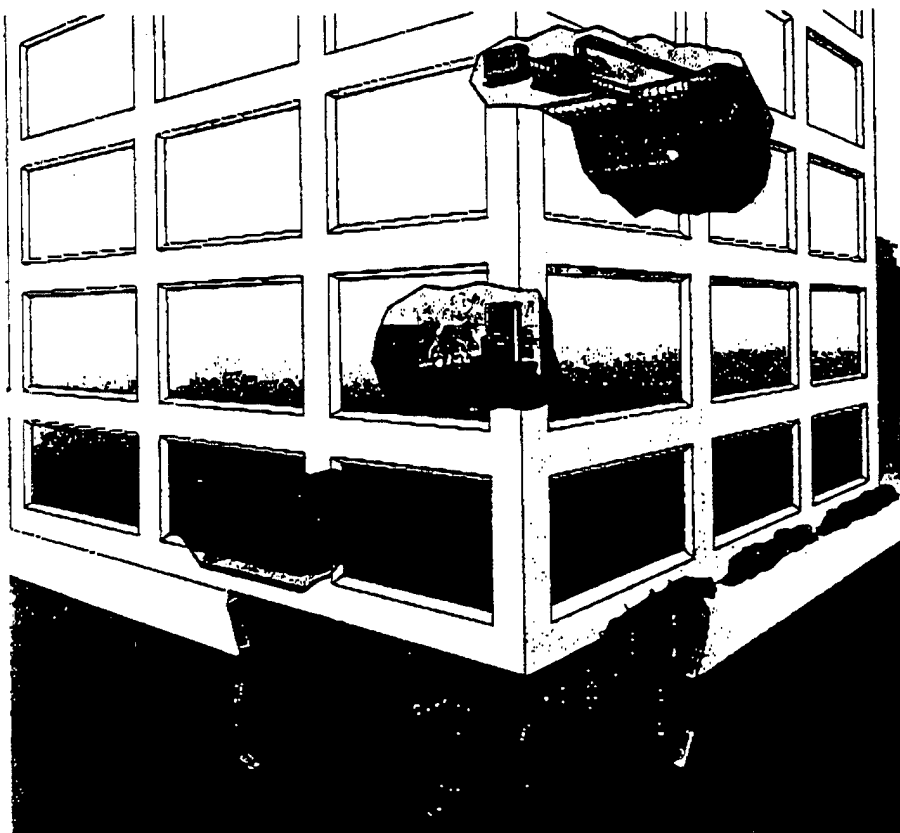
I	DRAWING NO. OR PAR. NO.	COMMENTS	REVIEW ACTION
	Pg 8-18	Please briefly state how the capacity of the turbine generator was determined.	
8.	Pg 8-18 & Pg D23-3	The schematic diagrams indicate 400 psig steam leaving the heat recovery steam generator, but the calculations are based on 100 psig steam. Please clarify.	
9.	Pg 9-14	Revise SPB and SIR columns in Table 9-11 as discussed above in comment 6c.	
10.	Pg C-6	Correct spelling of "parallel" and "versus".	
11.	Pg D21-13	Why is belt friction mentioned with regard to chilled water pumps, which are normally direct drive?	
12.	Pg D23-2 & Pg D24-2	Does the cost for the gas turbine with generator include the heat recovery system? Please show this on the estimate.	
13.	Tab 23	The following questions refer to steam pressures:	
	a	Page D23-5 states that the heat recovery system produces 100 psig saturated steam. Can saturated steam be used in the turbines that drive the chillers?	
	b	The turbine inlet pressure quoted by FRY Equipment Co. on page D23-20 is 125 psig. Is this compatible with the 100 psig used in the calculations?	
	c	The steam flows and pipe sizes for the distribution system were calculated for 30 psig steam. Is this pressure compatible with the existing system?	
14.	Pg D23-16	Steam rates for the absorption chillers are shown at the top of the page. These should be shown in Tab 24, or at least be properly identified.	

APPENDIX B

TRANE TRACE 600 PROGRAM DESCRIPTION



TRACE® 600



TRACE 600 (Trane Air Conditioning Economics) has developed over the years into a state-of-the-art energy analysis program. The program takes you step by step from basic building parameters, such as geographic location, to powerful system modeling, such as ice storage systems. Once you have provided the necessary modeling information, TRACE 600 will do the rest of the work for you.

When the program is through executing, you will be provided with a full comparative analysis between the different systems you have modeled.

TRACE 600 gives you the power to ask "What if . . ." over and over again.



Hardware Requirements:

IBM AT or higher, or approved compatible, Math Co-Processor, 640K RAM, 10 Mbytes free on hard disk for programs, 6-10 Mbytes free for run-time files, DOS V3.1 or higher.

Software Cost:

\$1,795.00

Related Tools:

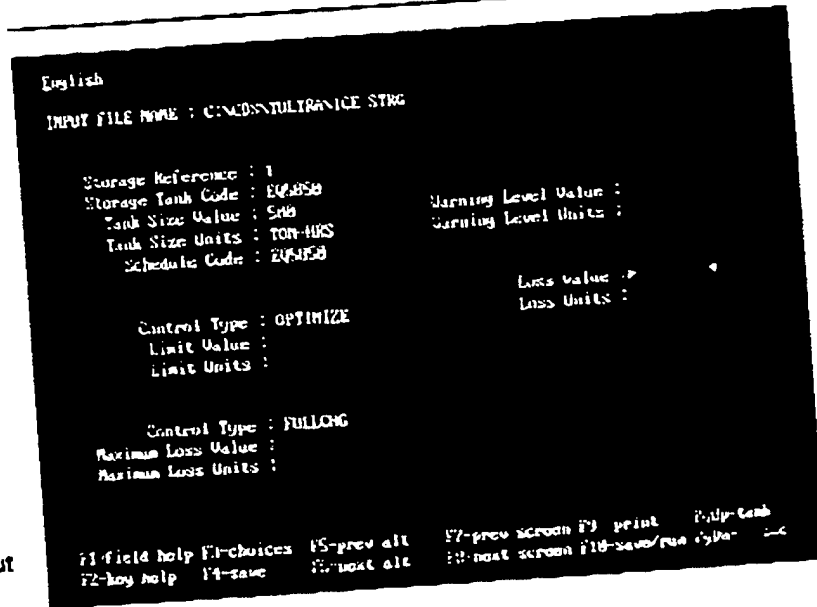
TRACE 600 Cookbook — Stuffed full of "recipes" to guide you through modeling some of the more complicated system options.

Building Templates — An extensive set of pre-input building files which can quickly be modified to represent your building for analysis.

TRACE® 600

The following descriptions represent just some of the advanced features provided by TRACE 600...

- Exhaust Air Heat Recovery can quickly be added to your system model. For example, you may consider coil to coil heat recovery, which typically recovers between 50 and 60 percent of both sensible and latent heat.
- An increasing number of building designs are taking advantage of daylighting, which is the use of sunlight, rather than electric lights, to illuminate a building interior. A quick daylighting model can reveal the fantastic savings possible.
- As utility rates skyrocket across the country, greater emphasis has been put on off-peak consumption. Thermal storage has proven to be a very effective method of achieving this goal. TRACE 600 allows you to determine just how effective thermal storage would be in your building.
- Another method for reducing utility bills is demand limiting. TRACE 600 can simulate the prioritized shutdown of equipment when peak demand approaches pre-defined limits.
- A greater number of chillers are being arranged using hydraulically decoupled piping. By modeling this very energy efficient system, you can consider whether the energy savings will pay back the increase in piping required.
- For applications which have waste heat, or in areas with high electricity rates, an absorption chiller may be considered. Even applications which require cogeneration may be easily modeled using the power of TRACE 600!
- Free cooling options have proven cost-effective in many applications. TRACE 600 can model several methods of free cooling, such as Plate-and-Frame, Heat Exchanger, Refrigerant Migration and Strainer Cycles.



**TRANE**

Software Bulletin

Library	Product Literature
Product Section	Software Services
Product	TRACE
Model	000
Literature Type	Software Bulletin
Sequence	15
Date	October 1991
File No.	PL-SS-TRACE-000-SFB-15-1091
Supersedes	

Ordering No.

TRACE-SFB-15

TRACE® 600 Demo Disk

Welcome to the TRACE 600 and TRACE Easy demonstration diskette and thanks for your interest in these programs. We sincerely feel that with proper use, these tools can significantly increase the profitability of your firm.

To make investigating this software as simple as possible we have categorized this bulletin as shown in the next column.

While there are no rules, we suggest you read through sections I and II, then load the demo program on your computer. Once you have the program up and running, use sections III and IV to guide you through the input, execution and output phases of the various programs. Then finish up by reading sections V and VI.

Contents

- I. Introduction and History of TRACE.
- II. Hardware Requirements and Installation of Demo Diskette.
- III. Step-by-Step Overview of:
 - A. TRACE Easy
 - B. TRACE 600
 - C. TRACE Economics
- IV. Discussion of Utility Programs.
- V. Actual Program Capabilities.
- VI. Concluding Remarks and Ordering Information.

Thanks again for your interest and we hope you find this demonstration both enjoyable and educational!

I. Introduction and History of TRACE

The TRACE (Trane Air Conditioning Economics) Program was first developed by The Trane Company in 1972. The purpose of the program is to provide an energy and economic analysis tool for use by HVAC designers as they investigate system, equipment and control options for particular applications. Of course, during the 1970's the program was only available through time-share services on mainframe computers. In 1988 we released the sixth generation of TRACE, this time as a program that operates on desktop personal computers. Contrary to intuition, the capabilities of the P.C. version of TRACE are much greater than the preceding mainframe computer generations.

Improved modeling flexibility and complete control of execution make TRACE 600 a truly remarkable program. For many years, we listened to the needs of the HVAC design community and incorporated many of the suggestions into TRACE 600. At the same time, we heard the need for a simplified version for those jobs that do not require investigation of sophisticated control strategies, thermal storage, cogeneration, etc. TRACE Easy was developed simultaneously with TRACE 600 to meet this need.

With fewer than half of the input fields of TRACE 600 and an execution speed about 40% faster, TRACE Easy provides simple-to-input, yet

accurate, energy and economic analysis for less sophisticated applications. In addition, if an analysis is started with TRACE Easy and then you find that an option such as thermal storage should be investigated, the input can be converted to TRACE 600 in just a couple of seconds.

Never before have such powerful and easy to use energy and economic analysis tools been so readily available. But even with the best software, technical support is critical for optimum use. The

C.D.S. Support Center is available Monday through Friday from 8:00 am to 6:00 pm Central time. We have six full-time engineers and software specialists available to help you with your technical questions. Give us a call at (608) 787-3926 if we can be of assistance.

Good luck with the demonstration programs and we hope that you find ways that TRACE can help improve YOUR business!

II. Hardware Requirements and Installation of Demo Diskette

Hardware Requirements

Because the demonstration program you are about to run is just a reduced form of the actual TRACE program, the hardware requirements are the same.

- IBM Compatible Personal Computer
- Minimum 286 CPU
- Math Co-processor
- Minimum 6 Mbytes free on hard disk.

If you have a 386 or 486 CPU, the program will execute faster. For the actual programs, reserve about 20 Mbytes of hard disk space for the program and your data files.

If your computer does not have a math co-processor, you can still install the demo diskette and view the input screens and sample data, but the program will not execute.

Installation Procedure

To install the demo diskette, make sure you have at least 6 Mbytes free on your hard disk. Then:

1. Move to the root directory on your computer. (i.e. type: `cd\` and press Enter) You should see the prompt `C:\` (or `D:\`, `E:\`, etc. if you have a different hard disk designator).
2. Place the demo diskette in your floppy drive.
3. Type the command `A:CDSINST` at the hard disk prompt and press Enter. (If your floppy drive is not designated as the 'A' drive, replace the 'A' in the preceding command with the appropriate drive letter.)

4. The program will execute a menu to guide you through the rest of the installation procedure. All you have to do is carefully read what is displayed on your computer screen.

5. Once the installation is complete, press the Esc (escape) key to exit the installation program.

The installation program has now created a subdirectory called DEMO, and has placed the files in the proper subdirectories. To start the program:

6. Move to the DEMO subdirectory by typing `cd\demo` and pressing Enter.

7. Type `go` and press Enter.

You should now see a menu that displays TRACE 600 and TRACE Easy demonstration programs as shown below.

Trace 600 Demo Menu

```
Trace Easy
Trace 600
Trace 600 Economics
Trace 600 Utilities
```

If you run into any difficulty, feel free to call technical support at (608) 787-3926. We will help you successfully complete your installation.

TRACE Sum Specification

(Used to sum building loads for the Tech Area and LC-38 chiller studies)

At times in the past TRACE 600 users have requested the ability to take outputs from a number of different buildings and combine them into one run for purposes of running Equipment and Economic alternatives. This can commonly happen if a user has a number of buildings on a central chilled plant - such as in a university setting. In passionately serving our customers a new utility has been developed. It is referred to here as TRACE Sum.

TRACE Sum (T6SUM.EXE) is a program which will take TRACE alternatives and sum the loads. These loads will then be available to read into the Equipment section of TRACE.

Requirements

- 1) Read a maximum of ten input TRACE alternatives. The drive and path of each alternative must be input.
- 2) All alternatives must have been run the same number of simulation months.
- 3) All alternatives must have their OD, OS and DBS files available.
- 4) User must specify name and location of desired output file. This file will be overwritten completely, thus the user should not have any input he/she wants to keep in this file name.
- 5) T6SUM TM, OD1 and OS1 and EXE files must all be in the same subdirectory. This will happen automatically during installation. If one somehow gets erased it will need to be re-installed.
- 6) All 'loads' will be summed - including airflows, lighting, etc. Since airflows may actually be from a combination of constant and variable volume systems it is not wise to use a TRACE Sum to analyze different fans. The sums of all the loads will be put into the output file as if there is one airside system.
- 7) Get into the \CDS\TULTRA subdirectory and type T6SUM.

Next Step

After the user has performed the TRACE Sum (T6SUM), he must go into the input (TM) file and

- 1) Input the weather location
- 2) Input the first and last months of energy simulation (11 Card) if not JAN through DEC.
- 3) Input the Equipment section of the program. For the assignment of cooling and heating loads, remember that the TRACE Sum has its loads in the first (only) system.
- 4) Edit the input.
- 5) Run **only** the Equipment section of the program.

APPENDIX C
PROGRAM DOCUMENTATION SUPPORT DATA

1. COMPONENT ARMY		FY 1996 MILITARY CONSTRUCTION PROJECT DATA		2. DATE 12 NOV 92	
3. INSTALLATION AND LOCATION White Sands Missile Range, New Mexico			4. PROJECT TITLE ECIP HVAC / Lighting Upgrade - Building P300		
5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NO.	8. PROJECT COST (\$000) 650		
9. COST ESTIMATES					
ITEM	U/M	QUANTITY	UNIT COST	COST (\$000)	
Primary Facility:					
a. Convert 7 air handling units (AHUs) and air distribution systems to variable air volume (VAV).	LS			528	
b. Replace one air-cooled chiller with a water-cooled chiller.					
c. Install a 1,000 ton-hour chilled water thermal storage system.					
d. Replace standard fluorescent lamps and ballasts with reduced-wattage fluorescent lamps and ballasts.					
Supporting Facilities:					
Design Cost	LS			<u>32</u>	
Estimated Contract Cost				560	
Contingency (10%)	LS			<u>56</u>	
Subtotal				616	
Supervision, Inspection and Overhead (5.5%)	LS			34	
Category E Equipment				<u>0</u>	
TOTAL REQUEST				650	
TOTAL REQUEST (ROUNDED)				650	
10. DESCRIPTION OF PROPOSED CONSTRUCTION					
<p>The proposed construction on building P300 at the White Sand Missile Range consists of the following:</p> <ul style="list-style-type: none"> • Convert four single zone and three dual-duct air handling units to VAV systems by installing variable air volume mixing boxes and variable frequency drives. Perform all necessary mechanical, electrical, and support work; • Remove a 100 ton air-cooled chiller and install a new 100 ton water-cooled chiller. Connect the new chiller to an existing cooling tower. Perform all necessary mechanical, electrical, and support work; • Install a 1,000 ton-hour chilled water thermal storage system and perform all mechanical, electrical and support work to integrate the thermal storage system into the existing chilled water system; • Replace 1,652 standard 4 ft. fluorescent lamps with reduced-wattage fluorescent lamps; replace 808 standard fluorescent ballasts with reduced-wattage ballasts. 					

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1 DEC 76

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UNTIL EXHAUSTED

PAGE NO. 1

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(WHEN DATA IS ENTERED)

1. COMPONENT ARMY	FY 1996 MILITARY CONSTRUCTION PROJECT DATA	2. DATE 12 NOV 92
3. INSTALLATION AND LOCATION White Sands Missile Range, New Mexico		
4. PROJECT TITLE ECIP HVAC / Lighting Upgrade - Building P300		5. PROJECT NUMBER
11. REQUIREMENT PROJECT: Conversion of the existing single zone AHUs, dual-duct AHUs, and ductwork from constant volume air systems to variable air volume systems; the replacement of a 100 ton air-cooled chiller with a water-cooled chiller; installation of a 1,000 ton-hour chilled water thermal storage system; and the replacement of standard fluorescent lamps and ballasts with reduced-wattage lamps and ballasts. REQUIREMENT: This project is required to reduce the natural gas and electrical consumption of the air handlers by reducing the air flow rates through variable volume air flow technology. This project is also required to reduce building electrical energy consumption of the lighting and air conditioning chillers by installing new equipment with improved efficiency. This project is also required to reduce the WSMR electrical demand charges via the installation of a chilled water thermal storage system to shift the chilled water equipment load to the off peak period. CURRENT SITUATION: The air system in building P300 was designed to handle high equipment heat gains in mission activity spaces. Over the years, most of the original mission equipment has been replaced with reduced wattage equipment. There have been no adjustments to fan supply air rates, although the supply air flow rates to various spaces have been adjusted many times. Most office areas are supplied by both the dual-duct AHUs and the single-zone AHUs via underfloor plenums, which results in overcooling. Building P300 is served by 8 chillers. The 8 chillers are connected to a chilled water loop that serves all 3 wings of the building, and operate 24 hours per day. This adds to the Main Post peak electrical demand. The main portion of the building is equipped with one 165 ton and one 200 ton electric centrifugal chiller, each served by a cooling tower. Six air-cooled chillers are located outside between the east and west wings. The normal sequence of chiller use is one of the two centrifugal units plus a single 50-ton air-cooled chiller, augmented by one of two 100-ton air-cooled chillers as necessary. The existing 200 ton centrifugal chiller is 10 years old and has approximately 13 years of remaining life. The existing 165 ton centrifugal chiller is original building equipment, and is used occasionally in place of the 200-ton chiller. The cooling load varies from a low of approximately 44 tons in winter to a summer high of 210 tons. Seldom are more than two chillers required to meet the load. Building P300 is equipped with a mixture of standard fluorescent lamps and ballasts and reduced-wattage lamps and ballasts.		

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1. COMPONENT ARMY	FY 1996 MILITARY CONSTRUCTION PROJECT DATA	2. DATE 12 NOV 92									
3. INSTALLATION AND LOCATION White Sands Missile Range, New Mexico											
4. PROJECT TITLE ECIP HVAC / Lighting Upgrade - Building P300		5. PROJECT NUMBER									
<p>IMPACT IF NOT PROVIDED:</p> <p>If this project is not funded, a reduction of 5,488 MBtu/yr cannot be achieved. Excessive amounts of natural gas and electricity will continue to be used, and there will be no contribution to energy reduction goals established for U.S. Army facilities by Army Headquarters.</p> <p>ADDITIONAL:</p> <p>This project complies with the scope and design criteria of CEHSC-FU-M "Energy Conservation Investment Program (ECIP) Guidance," that were in effect June 1991. The project has a Discounted Savings Ratio (SIR) of 2.3 and a simple payback of 4.7 years. The implementation of this project will provide an annual energy savings of 5,488 MBTU and an annual total dollar savings of \$105,972.</p> <p>Project validation will be through the use of electric meters on the existing UPS system to record electric consumption at Building P300.</p> <table> <tr> <td>ESTIMATED CONSTRUCTION START:</td> <td>OCT 1996</td> <td>INDEX: 2140</td> </tr> <tr> <td>ESTIMATED MIDPOINT OF CONSTRUCTION:</td> <td>JAN 1997</td> <td>INDEX: 2156</td> </tr> <tr> <td>ESTIMATED CONSTRUCTION COMPLETION:</td> <td>APR 1997</td> <td>INDEX: 2167</td> </tr> </table> <p>The above cost figures have been adjusted to January 1997 dollars, Index 2156, (midpoint of construction) from present day dollars (March 1992, Index 1822) by application of the TriService Military Construction Program (MCP) Index.</p>			ESTIMATED CONSTRUCTION START:	OCT 1996	INDEX: 2140	ESTIMATED MIDPOINT OF CONSTRUCTION:	JAN 1997	INDEX: 2156	ESTIMATED CONSTRUCTION COMPLETION:	APR 1997	INDEX: 2167
ESTIMATED CONSTRUCTION START:	OCT 1996	INDEX: 2140									
ESTIMATED MIDPOINT OF CONSTRUCTION:	JAN 1997	INDEX: 2156									
ESTIMATED CONSTRUCTION COMPLETION:	APR 1997	INDEX: 2167									

1. COMPONENT ARMY	FY 1996 MILITARY CONSTRUCTION PROJECT DATA	2. DATE 12 NOV 92
3. INSTALLATION AND LOCATION White Sands Missile Range, New Mexico		
4. PROJECT TITLE ECIP HVAC / Lighting Upgrade - Building P300		5. PROJECT NUMBER

EAST WING

WEST WING

SUPPLY AIR DUCT (TYP.)

DUAL DUCT MIXING BOX (TYP.)

ALL LOCATIONS ARE APPROXIMATE.

FIRST FLOOR PLAN

N

1. COMPONENT ARMY	FY 1996 MILITARY CONSTRUCTION PROJECT DATA	2. DATE 12 NOV 92
3. INSTALLATION AND LOCATION White Sands Missile Range, New Mexico		
4. PROJECT TITLE ECIP HVAC / Lighting Upgrade - Building P300		5. PROJECT NUMBER

EAST WING

WEST WING

ALL LOCATIONS ARE APPROXIMATE.

DUAL DUCT MIXING BOX (TYP)

SECOND FLOOR PLAN

N

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1 DEC 76

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C-6

Date: November 1992
Project Number:
Project Title: ECIP HVAC / Lighting Upgrade - Building P300

PROGRAMMING DOCUMENTATION

Methods of Analysis

Method of Analysis:

The existing air systems are constant volume, and sized for the original design cooling loads for the building. The underfloor supply air registers and transfer ducts that currently supply office spaces would be capped off, and only the existing dual duct air systems (DDs) would supply the offices. This would make more air available to the computer and mission equipment rooms, thereby improving the capability of the single zone units (SZUs) to serve the equipment areas. Both the SZUs and the DDs would be converted to VAV units with variable speed controllers and direct digital controls (DDCs). The DD mixing boxes would be converted to VAV mixing boxes. The proposed modification would reduce fan energy consumption, provide excellent flexibility in coping with future changes, correct the problem of overcooling the offices, and improve the cooling of equipment areas.

The current operational practice is to operate the 200 ton centrifugal chiller most of the year, and to augment the cooling capacity with one or both of the 100 ton air-cooled chillers as needed. Four 50 ton air-cooled units are used for standby, and operate occasionally. The air-cooled chillers use more kW/ton for cooling than the centrifugal chiller. The opportunity exists to improve the efficiency of the existing chiller plant by installing more water-cooled equipment. This should reduce electrical energy consumption and peak demand. The improved efficiency would be accomplished by the replacement of one of the two 100 ton air-cooled chillers with a new, 100 ton water-cooled reciprocating chiller connected in parallel to the existing 200 ton chiller. The other 5 air-cooled chillers would be retained for backup. The 3 water-cooled chillers would be served by the two existing cooling towers.

The installation of a chilled water thermal storage system will shift the operation of chillers, cooling towers, and condensate pumps to the off peak period, thereby producing a large reduction in electrical demand without any adverse effects on the air conditioning system.

The replacement of standard 40 watt fluorescent lamps and standard ballasts with 34 watt lamps and reduced-wattage ballasts will maintain adequate lighting and reduce the air conditioning load. This will reduce electrical demand and conserve electrical energy.

The TRACE 600 program was used to compare the energy consumption of the existing building configuration verses the modified configuration. The baseline TRACE 600 model was modified to incorporate reduced lighting and VAV systems with variable speed control for the SZUs and DDs. The new water-cooled 100 ton reciprocating chiller and the chilled water thermal storage system were added to the equipment portion of the TRACE 600 program.

The hourly average day per month weather data used in the TRACE 600 program was weather for El Paso, Texas.

Date: November 1992
Project Number:
Project Title: ECIP HVAC / Lighting Upgrade - Building P300

PROGRAMMING DOCUMENTATION (CONTINUED)
Assumptions and Sample Calculations

Assumptions:

Gas cost = \$2.2124 /MBtu

Electric cost = \$0.0221 /kWh

Electric demand cost = \$19.50 /kW

Calculations:

Difference in Building P300 Energy Consumption (figures taken from TRACE 600 output reports):

Baseline annual kWh - Modified Configuration annual kWh =

$(4,675,776 - 3,285,543) = 1,390,233 \text{ kWh}$

Baseline annual gas - Modified Configuration annual gas =

$(2,355 - 1,612) = 743 \text{ MBtu}$

Baseline annual electric demand - Modified Configuration annual electric demand =

$(8,840 - 5,126) = 3,714 \text{ kW}$

Annual Recurring Maintenance

Cost Savings for the Chiller Plant with thermal storage (increased use of cooling towers) = (\$1,000)

Annual Recurring Maintenance Cost Savings for the AHUs = \$0

Annual Recurring Maintenance Cost Savings for the modified lighting = \$0

Date: November 1992
Project Number:
Project Title: ECIP HVAC / Lighting Upgrade - Building P300

PROGRAMMING DOCUMENTATION (CONTINUED)
Economic Analysis

Economic Analysis:

Summary:

<u>Project</u>	<u>Annual Energy Savings</u> <u>(MBtu/yr)</u>	<u>Total Annual Cost Savings</u> <u>(\$/yr)</u>	<u>SIR</u>	<u>Simple Payback</u> <u>(yrs)</u>
ECIP HVAC / Lighting Upgrade - Building P300	5,488	105,972	2.3	4.7

The Life Cycle Cost Analysis (LCCA) for the ECIP project is presented on the following page. The energy savings shown on the LCCA form take into account interactive effects of all energy conservation measures.

Individual LCCAs for the VAV conversion, chiller plant replacement, chilled water thermal storage, and modified lighting are included. Each modification qualifies independently for the ECIP program.

LIFE CYCLE COST ANALYSIS SUMMARY ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: White Sands Missile Range

REGION: 4

PROJECT NO: DACA 63-91-C-0152

PROJECT TITLE: BLDG. 300 - MODIFIED CONFIGURATION

FISCAL YEAR: 1997

DISCRETE PORTION NAME: TOTAL

ANALYSIS DATE: 10/22/92

ECONOMIC LIFE: 15

PREPARED BY: T. FORSTER

1 INVESTMENT

A. CONSTRUCTION COST	=	\$528,109
B. SIOH COST	(5.5% of 1A) =	\$29,048
C. DESIGN COST	(6.0% of 1A) =	\$31,687
D. ENERGY CREDIT	(1A + 1B + 1C) =	\$588,842
E. SALVAGE VALUE	=	\$0
F. TOTAL INVESTMENT	(1D - 1E) =	\$588,842

2 ENERGY SAVINGS (+) / COST (-)

FUEL TYPE	FUEL COST \$/MBTU (1)	SAVINGS MBTU/YR (2)	ANNUAL \$ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)
A. ELEC	\$6.48	4,745	\$30,723	10.79	\$331,501
B. DIST		0	\$0	11.57	\$0
C. NAT GAS	\$2.21	743	\$1,644	12.38	\$20,353
D. PAPER		0	\$0		\$0
E. COAL			\$0	11.35	\$0
F. TOTAL		5,488	32,367.0		\$351,854

3 NON-ENERGY SAVINGS (+) / COST (-)

A. ANNUAL RECURRING (+/-) (ELECT. DEMAND SAVINGS AND MAINTENANCE COST SAVINGS)	=		\$71,413	
1 DISCOUNT FACTOR	(From Table A-2) =	10.67		
2 DISCOUNTED SAVINGS (+) / COST (-)	(3A x 3A1) =		\$761,979	
B. NON-RECURRING (+/-)				
ITEM	YEAR OF	DISCOUNT	DISCOUNTED	
	SAVINGS (1)	OCCURRENCE (2)	FACTOR (3)	SAVINGS (4)
a. Utility rebate	\$54,788		0.96	\$52,596
b.	\$0		0.00	\$0
c.	\$0		0.00	\$0
d TOTAL	\$54,788			\$52,596
C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) / COST (-)		(3A2 + 3Bd4) =		\$814,576
D. PROJECT NON-ENERGY TEST				
1 25% MAXIMUM NON-ENERGY CALCULATION		(2F5 x 0.33) =		\$116,112
a IF 3D1 => 3C THEN GO TO 4				
b IF 3D1 < 3C THEN CALCULATE SIR		(2F5 + 3D1) / 1F =		0.79
c IF 3D1b => 1 THEN GO TO 4				
d IF 3D1b < 1 THEN PROJECT DOES NOT QUALIFY				

4 FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2F3 + 3A + (3B1d/15)) =	\$105,972
5 TOTAL NET DISCOUNTED SAVINGS	(2F5 + 3C) =	\$1,166,430
6 DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (IF SIR < 1 THEN PROJECT DOES NOT QUALIFY)	(5/1F) =	1.98
7 SIMPLE PAYBACK (SPB)	(1F/4) =	5.6

LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: White Sands Missile Range	REGION: 4	PROJECT NO: DACA 63-91-C-0152
PROJECT TITLE: BLDG. 300 - MODIFIED CONFIGURATION WO/THERMAL STORAGE		FISCAL YEAR: 1992
DISCRETE PORTION NAME: TOTAL		
ANALYSIS DATE: 10/22/92	ECONOMIC LIFE: 15	PREPARED BY: T. FORSTER

1 INVESTMENT

A. CONSTRUCTION COST	=	\$82,500
B. SIOH COST	(5.5% of 1A) =	\$4,538
C. DESIGN COST	(6.0% of 1A) =	\$4,950
D. ENERGY CREDIT	(1A + 1B + 1C) =	\$91,988
E. SALVAGE VALUE	=	\$0
F. TOTAL INVESTMENT	(1D - 1E) =	\$91,988

2 ENERGY SAVINGS (+) / COST (-)

FUEL TYPE	FUEL COST \$/MBTU (1)	SAVINGS MBTU/YR (2)	ANNUAL \$ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)
A. ELEC	\$6.48	(21)	(\$136)	10.79	(\$1,466)
B. DIST		0	\$0	11.57	\$0
C. NAT GAS	\$2.21	0	\$0	12.38	\$0
D. PAPER		0	\$0		\$0
E. COAL			\$0	11.35	\$0
F. TOTAL		(21)	(135.8)		(\$1,466)

3 NON-ENERGY SAVINGS (+) / COST (-)

A. ANNUAL RECURRING (+/-) (ELECT. DEMAND SAVINGS AND MAINTENANCE COST SAVINGS)	=		\$25,019	
1 DISCOUNT FACTOR	(From Table A-2) =	10.67		
2 DISCOUNTED SAVINGS (+) / COST (-)	(3A x 3A1) =		\$266,947	
B. NON-RECURRING (+/-)				
ITEM	YEAR OF	DISCOUNT	DISCOUNTED	
	SAVINGS (1)	OCCURRENCE (2)	FACTOR (3)	SAVINGS (4)
a. Utility rebate	\$54,788		0.96	\$52,596
b.	\$0		0.00	\$0
c.	\$0		0.00	\$0
d TOTAL	\$54,788			\$52,596
C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) / COST (-)		(3A2 + 3Bd4) =		\$319,544
D. PROJECT NON-ENERGY TEST				
1 25% MAXIMUM NON-ENERGY CALCULATION		(2F5 x 0.33) =		(\$484)
a IF 3D1 => 3C THEN GO TO 4				
b IF 3D1 < 3C THEN CALCULATE SIR		(2F5 + 3D1) / 1F =		-0.02
c IF 3D1b => 1 THEN GO TO 4				
d IF 3D1b < 1 THEN PROJECT DOES NOT QUALIFY				

4 FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2F3 + 3A + (3B1d/15)) =	\$27,074
5 TOTAL NET DISCOUNTED SAVINGS	(2F5 + 3C) =	\$318,078
6 DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (IF SIR < 1 THEN PROJECT DOES NOT QUALIFY)	(5/1F) =	3.46
7 SIMPLE PAYBACK (SPB)	(1F/4) =	3.40

LIFE CYCLE COST ANALYSIS SUMMARY ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: White Sands Missile Range REGION: 4 PROJECT NO: DACA 63-91-C-0152
PROJECT TITLE: BLDG. 300 - MOD. CONFIG. W/O VARIABLE AIR VOLUME SYSTEMS ON AHUs FISCAL YEAR: 1992
DISCRETE PORTION NAME: TOTAL
ANALYSIS DATE: 10/22/92 ECONOMIC LIFE: 15 PREPARED BY: T. FORSTER

1 INVESTMENT

A. CONSTRUCTION COST	=	\$268,913
B. SIOH COST	(5.5% of 1A) =	\$14,790
C. DESIGN COST	(6.0% of 1A) =	\$16,135
D. ENERGY CREDIT	(1A + 1B + 1C) =	\$299,838
E. SALVAGE VALUE	=	\$0
F. TOTAL INVESTMENT	(1D - 1E) =	—————> \$299,838

2 ENERGY SAVINGS (+) / COST (-)

FUEL TYPE	FUEL COST \$/MBTU (1)	SAVINGS MBTU/YR (2)	ANNUAL \$ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)
A. ELEC	\$6.48	3,940	\$25,514	10.79	\$275,300
B. DIST		0	\$0	11.57	\$0
C. NAT GAS	\$2.21	761	\$1,684	12.38	\$20,843
D. PAPER		0	\$0		\$0
E. COAL			\$0	11.35	\$0
F. TOTAL		4,701	27,198.0		—————> \$296,143

3 NON-ENERGY SAVINGS (+) / COST (-)

A.	ANNUAL RECURRING (+/-) (ELEC. DEMAND SAVINGS)	=		\$17,336	
	1 DISCOUNT FACTOR	(From Table A-2) =	10.67		
	2 DISCOUNTED SAVINGS (+) / COST (-)	(3A x 3A1) =		\$184,970	
B.	NON-RECURRING (+/-)				
	ITEM	YEAR OF	DISCOUNT	DISCOUNTED	
		SAVINGS (1)	OCCURRENCE (2)	FACTOR (3)	SAVINGS (4)
	a.	\$0		0.00	\$0
	b.	\$0		0.00	\$0
	c.	\$0		0.00	\$0
	d TOTAL	\$0			\$0
C.	TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) / COST (-)		(3A2 + 3Bd4) =		\$184,970
D.	PROJECT NON-ENERGY TEST				
	1 25% MAXIMUM NON-ENERGY CALCULATION		(2F5 x 0.33) =		\$97,727
	a IF 3D1 => 3C THEN GO TO 4				
	b IF 3D1 < 3C THEN CALCULATE SIR		(2F5 + 3D1) / 1F =		1.31
	c IF 3D1b => 1 THEN GO TO 4				
	d IF 3D1b < 1 THEN PROJECT DOES NOT QUALIFY				

4 FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2F3 + 3A + (3B1d/15)) =	\$44,533
5 TOTAL NET DISCOUNTED SAVINGS	(2F5 + 3C) =	\$481,113
6 DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR)	(5/1F) =	1.60
(IF SIR < 1 THEN PROJECT DOES NOT QUALIFY)		
7 SIMPLE PAYBACK (SPB)	(1F/4) =	6.73

LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: White Sands Missile Range	REGION: 4	PROJECT NO: DACA 63-91-C-0152
PROJECT TITLE: BLDG. 300 - MODIFIED CONFIG. W/O ENERGY EFFICIENT LIGHTING		FISCAL YEAR: 1992
DISCRETE PORTION NAME: TOTAL		
ANALYSIS DATE: 10/22/92	ECONOMIC LIFE: 25	PREPARED BY: T. FORSTER

1 INVESTMENT

A. CONSTRUCTION COST	=	\$38,783
B. SIOH COST	(5.5% of 1A) =	\$2,133
C. DESIGN COST	(6.0% of 1A) =	\$2,327
D. ENERGY CREDIT	(1A + 1B + 1C) =	\$43,243
E. SALVAGE VALUE	=	\$0
F. TOTAL INVESTMENT	(1D - 1E) =	\$43,243

2 ENERGY SAVINGS (+) / COST (-)

FUEL TYPE	FUEL COST \$/MBTU (1)	SAVINGS MBTU/YR (2)	ANNUAL \$ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)
A. ELEC	\$6.48	77	\$498	15.23	\$7,592
B. DIST		0	\$0	17.28	\$0
C. NAT GAS	\$2.21	(28)	(\$61)	19.64	(\$1,195)
D. PAPER		0	\$0		\$0
E. COAL			\$0	16.22	\$0
F. TOTAL		49	437.6		\$6,396

3 NON-ENERGY SAVINGS (+) / COST (-)

A. ANNUAL RECURRING (+/-) (ELEC. DEMAND SAVINGS)	=	\$5,655
1 DISCOUNT FACTOR	(From Table A-2) =	14.68
2 DISCOUNTED SAVINGS (+) / COST (-)	(3A x 3A1) =	\$83,015

B. NON-RECURRING (+/-)

ITEM	SAVINGS (1)	YEAR OF OCCURRENCE (2)	DISCOUNT FACTOR (3)	DISCOUNTED SAVINGS (4)
a.	\$0		0.00	\$0
b.	\$0		0.00	\$0
c.	\$0		0.00	\$0
d TOTAL	\$0			\$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) / COST (-)	(3A2 + 3Bd4) =	\$83,015
---	----------------	----------

D. PROJECT NON-ENERGY TEST

1 25% MAXIMUM NON-ENERGY CALCULATION	(2F5 x 0.33) =	\$2,111
a IF 3D1 => 3C THEN GO TO 4		
b IF 3D1 < 3C THEN CALCULATE SIR	(2F5 + 3D1) / 1F =	0.20
c IF 3D1b => 1 THEN GO TO 4		
d IF 3D1b < 1 THEN PROJECT DOES NOT QUALIFY		

4 FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2F3 + 3A + (3B1d/25)) =	\$6,093
5 TOTAL NET DISCOUNTED SAVINGS	(2F5 + 3C) =	\$89,412
6 DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR)	(5/1F) =	2.07
(IF SIR < 1 THEN PROJECT DOES NOT QUALIFY)		
7 SIMPLE PAYBACK (SPB)	(1F/4) =	7.10

LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: White Sands Missile Range	REGION: 4	PROJECT NO: DACA 63-91-C-0152
PROJECT TITLE: BLDG. 300 - MOD. CONFIG. W/O CONSOLIDATED CHILLER PLANT		FISCAL YEAR: 1992
DISCRETE PORTION NAME: TOTAL		
ANALYSIS DATE: 10/22/92	ECONOMIC LIFE: 25	PREPARED BY: T. FORSTER

1 INVESTMENT

A. CONSTRUCTION COST	=		\$56,100
B. SIOH COST	(5.5% of 1A) =		\$3,086
C. DESIGN COST	(6.0% of 1A) =		\$3,366
D. ENERGY CREDIT	(1A + 1B + 1C) =		\$62,552
E. SALVAGE VALUE	=		\$0
F. TOTAL INVESTMENT	(1D - 1E) =	—————>	\$62,552

2 ENERGY SAVINGS (+) / COST (-)

FUEL TYPE	FUEL COST \$/MBTU (1)	SAVINGS MBTU/YR (2)	ANNUAL \$ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)
A. ELEC	\$6.48	617	\$3,995	15.23	\$60,839
B. DIST		0	\$0	17.28	\$0
C. NAT GAS	\$2.21	0	\$0	19.64	\$0
D. PAPER		0	\$0		\$0
E. COAL			\$0	16.22	\$0
F. TOTAL		617	3,994.7	—————>	\$60,839

3 NON-ENERGY SAVINGS (+) / COST (-)

A. ANNUAL RECURRING (+/-) (ELEC. DEMAND SAVINGS + MAINTENANCE COST SAVINGS)	=		\$3,212
1 DISCOUNT FACTOR	(From Table A-2) =	14.68	
2 DISCOUNTED SAVINGS (+) / COST (-)	(3A x 3A1) =		\$47,152
B. NON-RECURRING (+/-)			
ITEM	SAVINGS (1)	YEAR OF OCCURRENCE (2)	DISCOUNT FACTOR (3)
a.	\$0		0.00
b.	\$0		0.00
c.	\$0		0.00
d TOTAL	\$0		\$0
C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) / COST (-)		(3A2 + 3Bd4) =	\$47,152
D. PROJECT NON-ENERGY TEST			
1 25% MAXIMUM NON-ENERGY CALCULATION		(2F5 x 0.33) =	\$20,077
a IF 3D1 => 3C THEN GO TO 4			
b IF 3D1 < 3C THEN CALCULATE SIR		(2F5 + 3D1) / 1F =	1.29
c IF 3D1b => 1 THEN GO TO 4			
d IF 3D1b < 1 THEN PROJECT DOES NOT QUALIFY			

4 FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2F3 + 3A + (3B1d/25)) =		\$7,207
5 TOTAL NET DISCOUNTED SAVINGS	(2F5 + 3C) =		\$107,991
6 DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (IF SIR < 1 THEN PROJECT DOES NOT QUALIFY)	(5/1F) =		1.73
7 SIMPLE PAYBACK (SPB)	(1F/4) =		8.68

COST ESTIMATE ANALYSIS										INVIATION/CONTRACTOR		EFFECTIVE PRICING DATE		DATE PREPARED	
For use of this form, see TM 5-900-2; the proponent agency is USACE.												November 1992		November 1992	
PROJECT		White Sands Missile Range ES05								CODE (Check one)		DRAWING NO. ECIP HVAC/ Lighting Upgrade-Bldg300		SHEET 1 OF 3 SHEETS	
LOCATION		White Sands Missile Range, New Mexico								<input checked="" type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> OTHER		ESTIMATOR A. Niemeyer		CHECKED BY T. Forster	
TASK DESCRIPTION	QUANTITY			LABOR			EQUIPMENT		MATERIAL		TOTAL	SHIPPING			
	NO. OF UNITS	UNIT MEAS	MH	TOTAL HRS	UNIT PRICE	COST	UNIT PRICE	COST	UNIT PRICE	COST		UNIT WT	TOTAL WT		
Sheet 2 of 3											256,927				
Sheet 3 of 3											95,876				
Subtotal											352,803				
Contractor OH @ 15%											52,921				
Contractor Profit @ 10%											40,572				
Construction Cost											446,296				
Army Construction				January 1997 Index (2156)					March 1992 Index (1822)		81,813				
Program Cost Growth															
Factor @ 18.3%															
Total Adjusted											528,109				
Construction Cost															
TOTAL THIS SHEET															

COST ESTIMATE ANALYSIS										INVIATION/CONTRACTOR		EFFECTIVE PRICING DATE		DATE PREPARED	
For use of this form, see TM 5-800-2; the proponent agency is USACE.												November 1992		November 1992	
PROJECT White Sands Missile Range ES05										CODE (Check one) <input checked="" type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C		DRAWING NO. ECIP HVAC/ Lighting Upgrade-BldgP300		SHEET 2 OF 3 SHEETS	
LOCATION White Sands Missile Range, New Mexico										<input type="checkbox"/> OTHER		ESTIMATOR A. Niemeyer		CHECKED BY T. Forster	
TASK DESCRIPTION	QUANTITY		MH	LABOR		EQUIPMENT		MATERIAL		TOTAL	SHIPPING				
	NO. OF UNITS	UNIT MEAS		TOTAL HRS	UNIT PRICE	COST	UNIT PRICE	COST	UNIT PRICE		COST	UNIT WT	TOTAL WT		
Remove Mixing Boxes	1	LS													
Variable Frequency Drives															
Main Building	3	EA		1210	3,630				12,750	38,250	41,880				
East & West Wings	4	EA		970	3,880				5,507	22,028	25,908				
VAV Mixing Boxes	74	EA		73	5,400				495	36,630	42,030				
VAV Mixing Box Controls	74	EA		292	21,600				687.5	50,875	72,475				
Controls for AHUs	7	EA		631.4	4,420				1,265	8,855	13,275				
Modify Ductwork; Test & Balance	1	EA			14,479						14,479				
100 Ton Water-Cooled Chiller	1	EA			7,200					37,000	44,200				
TOTAL THIS SHEET											256,927				

COST ESTIMATE ANALYSIS										INVOITATION/CONTRACTOR		EFFECTIVE PRICING DATE		DATE PREPARED	
For use of this form, see TM 5-900-2; the proponent agency is USACE.												November 1992		November 1992	
PROJECT White Sands Missile Range ES0S										CODE (Check one) <input checked="" type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C		DRAWING NO. ECIP HVAC/ Lighting Upgrade-BldgP30		SHEET 3 OF 3 SHEETS	
LOCATION White Sands Missile Range, New Mexico										<input type="checkbox"/> OTHER		ESTIMATOR A. Niemeyer		CHECKED BY T. Forster	
TASK DESCRIPTION	QUANTITY		MH	LABOR		EQUIPMENT		MATERIAL		TOTAL	SHIPPING				
	NO. OF UNITS	UNIT MEAS		TOTAL HRS	UNIT PRICE	COST	UNIT PRICE	COST	UNIT PRICE		COST	UNIT WT	TOTAL WT		
Install 1,000 ton -hr.	1	LS													
Chilled water thermal storage															
Install energy efficient lamps and ballasts															
4 ft. efficient lamps	1,652	ea		1.92	3,172			1.73	2,860	6,032					
Efficient ballasts	826	ea		18.57	15,336			11.25	9,290	24,626					
TOTAL THIS SHEET													95,876		

MONTHLY ENERGY CONSUMPTION - ALTERNATIVE 1 (BASELINE - BLDG P300)

----- MONTHLY ENERGY CONSUMPTION -----

Month	ELEC On Peak (kWh)	DEMAND On Peak (kW)	GAS On Peak (Therm)	WATER (1000 GL)	GAS DMND On Peak (Thrm/hr)
Jan	370,311	664	6,458	145	14
Feb	335,056	663	5,227	135	14
March	378,559	692	2,512	182	8
April	374,522	726	585	227	3
May	406,945	754	9	326	0
June	414,722	831	0	382	0
July	433,778	837	0	408	0
Aug	434,746	829	0	398	0
Sept	398,870	757	0	321	0
Oct	394,963	729	782	248	4
Nov	362,831	690	2,815	175	9
Dec	370,472	668	5,163	156	11
Total	4,675,776	837	23,551	3,104	14

Building Energy Consumption = 301,008 (Btu/Sq Ft/Year)
Source Energy Consumption = 302,206 (Btu/Sq Ft/Year)

Floor Area = 60,840 (Sq Ft)

$$\Sigma \text{ monthly Kw} = 8840$$

MONTHLY ENERGY CONSUMPTION - ALTERNATIVE 1

MOD CONFIG - BLDG 300 WITHOUT THERM STOR *

----- MONTHLY ENERGY CONSUMPTION -----

Month	ELEC On Peak (kWh)	DEMAND On Peak (kW)	GAS On Peak (Therm)	WATER (1000 GL)	GAS DMND On Peak (Thrm/hr)
Jan	237,896	514	4,478	47	12
Feb	217,350	518	3,581	48	11
March	254,879	553	1,645	90	6
April	257,323	611	482	129	3
May	295,498	644	95	197	2
June	302,610	666	0	242	0
July	329,801	677	0	293	0
Aug	332,016	675	0	289	0
Sept	293,672	648	33	221	1
Oct	273,498	619	552	143	2
Nov	242,964	550	1,814	84	6
Dec	241,890	520	3,442	60	8
Total	3,279,396	677	16,123	1,843	12

Building Energy Consumption = 210,467 (Btu/Sq Ft/Year)
Source Energy Consumption = 211,287 (Btu/Sq Ft/Year)

Floor Area = 60,840 (Sq Ft)

* ALSO USED FOR THE BASELINE CONSUMPTION TO EVALUATE
THE INTERACTION EFFECTS OF VAV, LIGHTING AND CONSOLIDATED
CHILLER PLANT ECON.

MONTHLY ENERGY CONSUMPTION - ALTERNATIVE 2
MOD CONFIG - BLDG 300 WITHOUT VAV

----- MONTHLY ENERGY CONSUMPTION -----

Month	ELEC On Peak (kWh)	DEMAND On Peak (kW)	GAS On Peak (Therm)	WATER (1000 GL)	GAS DMND On Peak (Thrm/hr)
Jan	351,780	626	6,514	137	14
Feb	318,420	626	5,274	127	14
March	360,536	643	2,530	174	8
April	355,974	679	586	220	3
May	387,033	696	9	317	0
June	391,920	717	0	377	0
July	409,254	726	0	412	0
Aug	410,673	720	0	399	0
Sept	376,847	698	0	314	0
Oct	373,457	680	782	241	4
Nov	345,639	645	2,834	167	9
Dec	352,402	628	5,204	147	11
Total	4,433,935	726	23,732	3,032	14

Building Energy Consumption = 287,740 (Btu/Sq Ft/Year)
Source Energy Consumption = 288,947 (Btu/Sq Ft/Year)

Floor Area = 60,840 (Sq Ft)

MONTHLY ENERGY CONSUMPTION - ALTERNATIVE 3
 MOD CONFIG - BLDG 300 MINUS NEW CHIL PLT

----- MONTHLY ENERGY CONSUMPTION -----

Month	ELEC On Peak (kWh)	DEMAND On Peak (kW)	GAS On Peak (Therm)	WATER (1000 GL)	GAS DMND On Peak (Thrm/hr)
Jan	243,097	532	4,478	51	12
Feb	224,201	535	3,581	53	11
March	266,268	569	1,645	97	6
April	274,584	625	482	134	3
May	315,753	663	95	201	2
June	323,682	688	0	245	0
July	347,964	697	0	295	0
Aug	351,172	695	0	292	0
Sept	315,554	671	33	224	1
Oct	293,754	633	552	149	2
Nov	253,297	566	1,814	91	6
Dec	250,829	537	3,442	66	8
Total	3,460,157	697	16,123	1,896	12

Building Energy Consumption = 220,607 (Btu/Sq Ft/Year)
 Source Energy Consumption = 221,427 (Btu/Sq Ft/Year)

Floor Area = 60,840 (Sq Ft)

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MONTHLY ENERGY CONSUMPTION - ALTERNATIVE 4
 MOD CONFIG - BLDG 300 MINUS NEW LIGHTING

----- MONTHLY ENERGY CONSUMPTION -----

Month	ELEC On Peak (kWh)	DEMAND On Peak (kW)	GAS On Peak (Therm)	WATER (1000 GL)	GAS DMND On Peak (Thrm/hr)
Jan	239,240	535	4,413	48	12
Feb	218,464	540	3,512	48	11
March	257,005	582	1,615	92	6
April	258,996	638	471	132	3
May	298,098	668	96	201	2
June	304,984	690	0	247	0
July	331,335	701	0	298	0
Aug	333,978	699	0	295	0
Sept	295,765	672	34	226	1
Oct	276,112	635	544	147	2
Nov	244,796	578	1,785	86	6
Dec	243,175	547	3,379	60	8
Total	3,301,951	701	15,848	1,879	12

Building Energy Consumption = 211,280 (Btu/Sq Ft/Year)
 Source Energy Consumption = 212,085 (Btu/Sq Ft/Year)

Floor Area = 60,840 (Sq Ft)

1

SCOPE OF WORK

1.0 GENERAL

The work on Building P23640 shall upgrade the existing HVAC system and replace the existing fluorescent lighting system with an energy efficient fluorescent lighting system. The following sections list the specific tasks to be included in the work.

2.0 UPGRADE THE EXISTING HVAC SYSTEM

2.1.1 Upgrade AHU-1

AHU-1 conditions electronic equipment in two computer rooms, primarily through a raised-floor plenum. The conditioned area is approximately 2,480 sq.ft. AHU-1 currently delivers approximately 15,800 cfm using a 40 HP fan motor. The work to upgrade AHU-1 shall consist of the following:

- 1.) Replace the existing 40 HP fan motor with a down-sized high efficiency fan motor. The replacement motor size will be determined by a HVAC design analysis before installation.
- 2.) Resheave the fan to deliver approximately 4,290 cfm. The cooling load for the computer rooms served by AHU-1 shall be determined by a HVAC design analysis. The amount of conditioned air to be delivered by AHU-1 shall be determined from the cooling load via the HVAC design analysis.
- 3.) Determine the required air flows (from the HVAC design analysis) to areas served by AHU-1. Balance the air flows into these areas accordingly.

2.1.2 Upgrade AHU-2

AHU-2 provides comfort air conditioning to two computer rooms, an office area, and an electronics repair station. The conditioned area is approximately 4,200 sq.ft. AHU-2 delivers conditioned air at approximately 4,550 cfm using a 7.5 HP fan motor. The work to upgrade AHU-2 shall consist of the following:

- 1.) Install a chilled water coil. The chilled water coil size will be determined by a HVAC design analysis before installation.
- 2.) Install a dry-bulb economizer to control the position of outside air and return air dampers to provide mixed air temperature control. The following pneumatic control and HVAC components shall be installed to provide the economizer control:
 - o Receiver-controller
 - o Outside Air temperature sensor
 - o Return Air temperature sensor

- o Mixed Air temperature sensor
 - o Low-leakage return air damper with damper actuator
 - o Low-leakage outside air damper with damper actuator
- 3.) Determine the required air flows to areas served by AHU-2 by performing a HVAC design analysis. Balance the air flows into these areas accordingly.

2.1.3 Upgrade Chiller Control

The work to upgrade the chiller control shall consist of the following:

- 1.) Provide a reset chilled water supply temperature control to maintain a 55°F return chilled water temperature. The temperature control will be a 6°F reset.

3.0 UPGRADE THE EXISTING FLUORESCENT LIGHTING SYSTEM

3.1.1 Upgrade Fluorescent Lighting System

The existing fluorescent lighting system consists of fluorescent fixtures with standard lamps and ballasts. Each fluorescent fixture contains two 40 watt lamps and a magnetic ballast. The work to upgrade the fluorescent lighting system shall consist of the following:

- 1.) Replace the standard magnetic ballasts with low-wattage magnetic ballasts in approximately 190 fluorescent fixtures throughout the building.
- 2.) Replace approximately 380 standard 40 watt lamps with low-wattage (34 watt) fluorescent lamps in approximately 190 fluorescent fixtures throughout the building.

SCOPE OF WORK

1.0 GENERAL

The work on Building P23642 shall upgrade the existing HVAC system and replace the existing fluorescent lighting system with an energy efficient fluorescent lighting system. The following sections list the specific tasks to be included in the work.

2.0 UPGRADE THE EXISTING HVAC SYSTEM

2.1.1 Upgrade AHU-1

AHU-1 conditions a large vault which is now used as an office space. The vault originally contained process equipment that required large supply airflows, which the current use of the space does not. The conditioned area is approximately 2,090 sq.ft. AHU-1 delivers approximately 12,200 cfm using a 25 HP fan motor. The work to upgrade AHU-1 shall consist of the following:

- 1.) Replace the existing 25 HP fan motor with a down-sized high efficiency fan motor. The replacement motor size shall be determined by a HVAC design analysis before installation.
- 2.) Resheave the fan to deliver approximately 3,658 cfm. The cooling load for the office space served by AHU-1 shall be determined by a HVAC design analysis. The amount of conditioned air to be delivered by AHU-1 shall be determined from the cooling load via the HVAC design analysis.
- 3.) Install a dry-bulb economizer to control the position of outside air and return air dampers to provide mixed air temperature control. The following pneumatic control and HVAC components shall be installed to provide the economizer control:
 - o Receiver-controller
 - o Outside Air temperature sensor
 - o Return Air temperature sensor
 - o Mixed Air temperature sensor
 - o Refurbish return air damper and damper actuator
 - o Refurbish outside air damper and damper actuator
- 4.) Balance the supply air rates in accordance with the air flows calculated in the HVAC design analysis.

2.1.2 Upgrade AHU-2 & AHU-3

AHU-2 and AHU-3 provide comfort air conditioning to the west office wing, AHU-2 serving the north half and AHU-3 serving the south half of the wing. The conditioned area for each AHU is approximately 3,652 sq.ft. AHU-2 delivers conditioned air at approximately 10,043 cfm using a 10 HP fan motor. AHU-3 delivers conditioned air at approximately 8,217 cfm using a 10 HP fan motor. The work to upgrade AHU-2 and AHU-3 shall consist of the following:

- 1.) Replace the existing 10 HP fan motors with down-sized high efficiency fan motors. The replacement motor sizes shall be determined by a HVAC design analysis before installation.
- 2.) Reshelve the fans on AHU-2 and AHU-3 to deliver approximately 6,390 cfm each. The cooling loads for the office spaces served by AHU-2 and AHU-3 shall be determined by a HVAC design analysis. The amount of conditioned air to be delivered by AHU-2 and AHU-3 shall be determined from the cooling loads via the HVAC design analysis.
- 3.) Install dry-bulb economizers on AHU-2 and AHU-3 to control the position of outside air and return air dampers to provide mixed air temperature control. The following pneumatic control and HVAC components shall be installed to provide the economizer controls:
 - o Receiver-controllers
 - o Outside Air temperature sensors
 - o Return Air temperature sensors
 - o Mixed Air temperature sensors
 - o Low-leakage return air dampers with damper actuators
 - o Low-leakage outside air dampers with damper actuators
- 4.) Install an outside air louver in the concrete wall above the mechanical room door.
- 5.) Install ductwork from the outside air louver to the existing outside air ductwork common to both AHUs.
- 6.) Balance the supply air rates in accordance with the air flows calculated in the HVAC design analysis.

2.1.3 Upgrade Chiller Controls

The work to upgrade the chiller controls shall consist of the following:

- 1.) Provide a reset chilled water supply temperature control to maintain a 55°F return chilled water temperature on two 75 ton water-cooled reciprocating chillers. The temperature controls shall be a 6°F reset.

3.0 UPGRADE THE EXISTING FLUORESCENT LIGHTING SYSTEM

3.1.1 Upgrade Fluorescent Lighting System

The existing fluorescent lighting system consists of fluorescent fixtures with standard lamps and ballasts. Each fluorescent fixture contains two 40 watt lamps and a standard magnetic ballast. The work to upgrade the fluorescent lighting system shall consist of the following:

- 1.) Replace the standard magnetic ballasts with low-wattage magnetic ballasts in approximately 260 fluorescent fixtures throughout the building.
- 2.) Replace approximately 520 standard 40 watt lamps with low-wattage (34 watt) fluorescent lamps in approximately 260 fluorescent fixtures throughout the building.

SCOPE OF WORK

1.0 GENERAL

Building P24072 was constructed around 1956 as a radar transmitter building in support of the Nike Zeus program. This three story building, half of which is below grade, is characterized by heavy concrete construction, extensive air handling equipment, high capacity electrical transformers, and extensive fluorescent lighting. The building stood idle from approximately 1961 to 1965, and today serves as a maintenance facility for helicopter drones. Only a small portion of the building is in use. The main floor high bay area is the maintenance function area. The adjacent office is also used. A portion of the basement is used for storage, while the rest of the areas are unused.

The work on Building P24072 shall upgrade the HVAC controls on the main air handling unit (AHU) and replace the existing fluorescent lighting system with an energy efficient fluorescent lighting system. The following sections list the specific tasks to be included in the work.

2.0 UPGRADE THE HVAC CONTROLS

2.1.1 Upgrade HVAC Controls on AHU

The AHU conditions the entire building. The total area conditioned is approximately 33,125 sq.ft. The AHU operates without HVAC controls, it is either ON or OFF. The following pneumatic HVAC control components shall be installed to provide space temperature control:

- 1.) Setback/setup thermostat
- 2.) Pneumatic control valve for chilled water coil
- 3.) Pneumatic control valve for steam coil
- 4.) Pressure/Electric switch

3.0 UPGRADE THE EXISTING FLUORESCENT LIGHTING SYSTEM

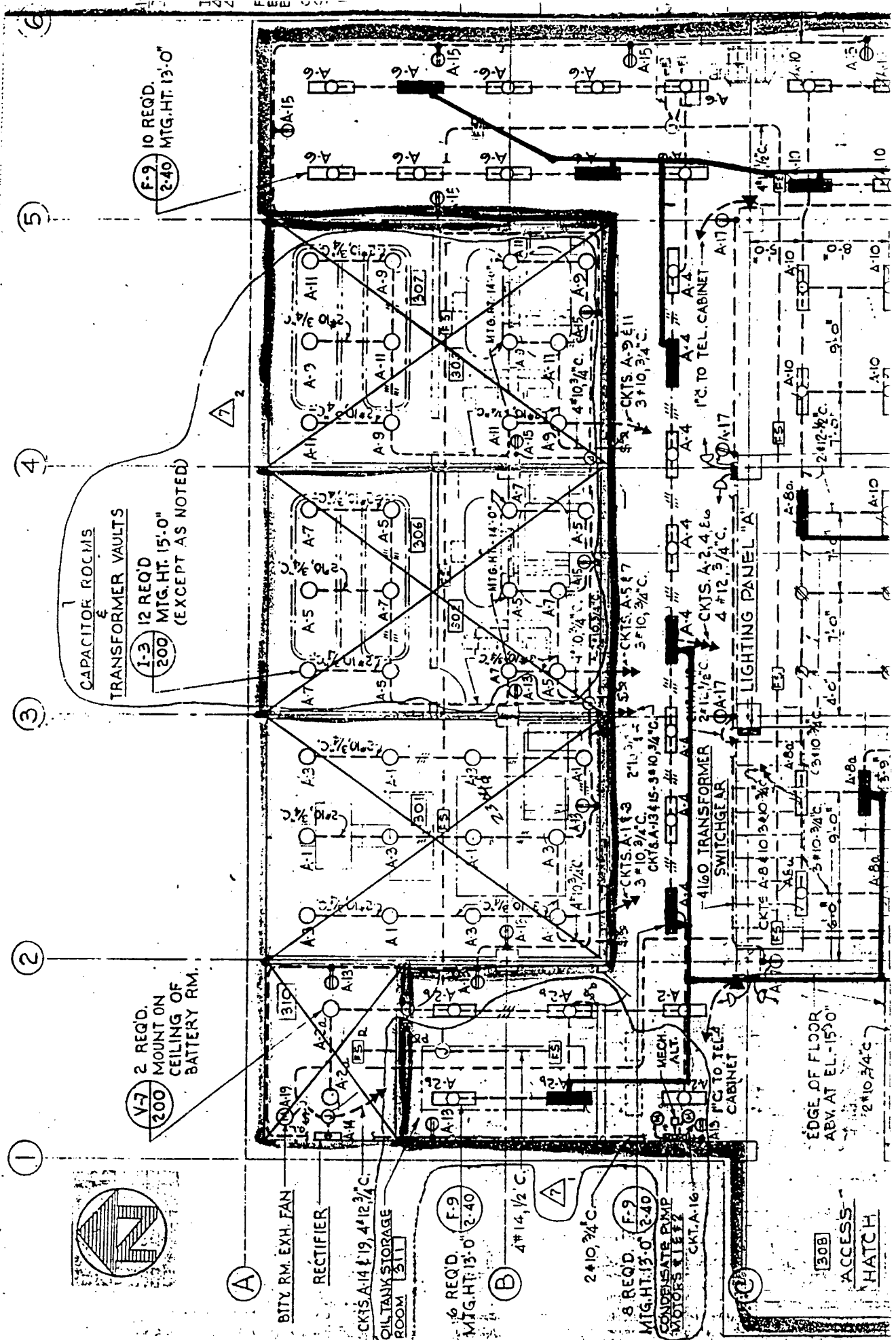
3.1.1 Upgrade Fluorescent Lighting System

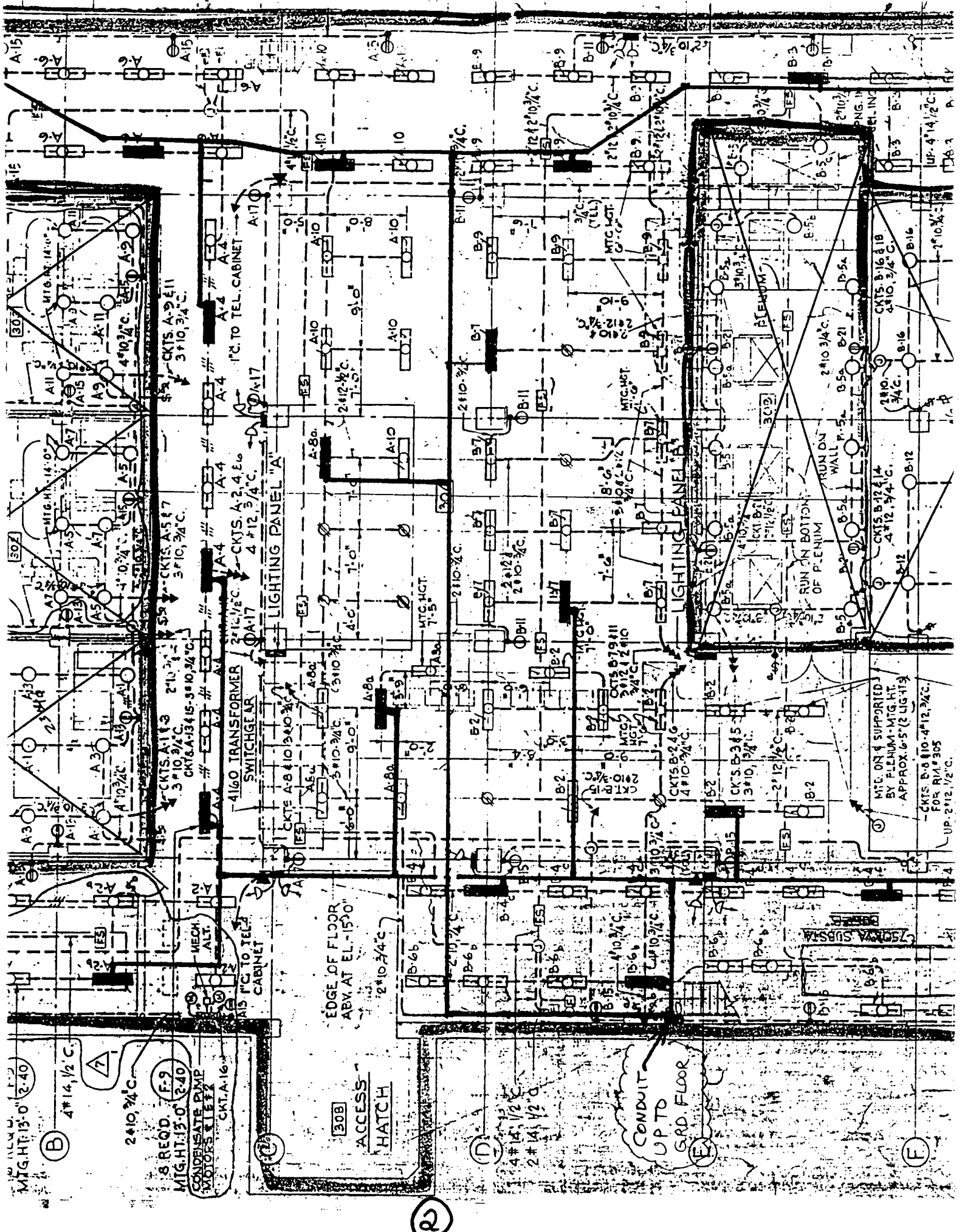
The existing fluorescent lighting system consists of fluorescent fixtures with standard lamps and ballasts. Each fluorescent fixture contains two 40 watt lamps and a standard magnetic ballast. Many of the fluorescent fixtures are either burned out or nearly so. The lights are never turned off because up to three days are required for many of the lamps to relight when turned on.

A lighting plan was developed to reduce the number of fluorescent lighting fixtures in unused and storage areas (see attached lighting plans). The lighting plan shall provide new wiring, switches, energy efficient fluorescent lamps, and energy efficient ballasts for the entire building. The basement and second floor areas of the building are primarily used for storage. The first floor (main floor high bay area) of the building is used as a maintenance area, office area, and lounge area. The work to upgrade the fluorescent lighting system shall consist of the following:

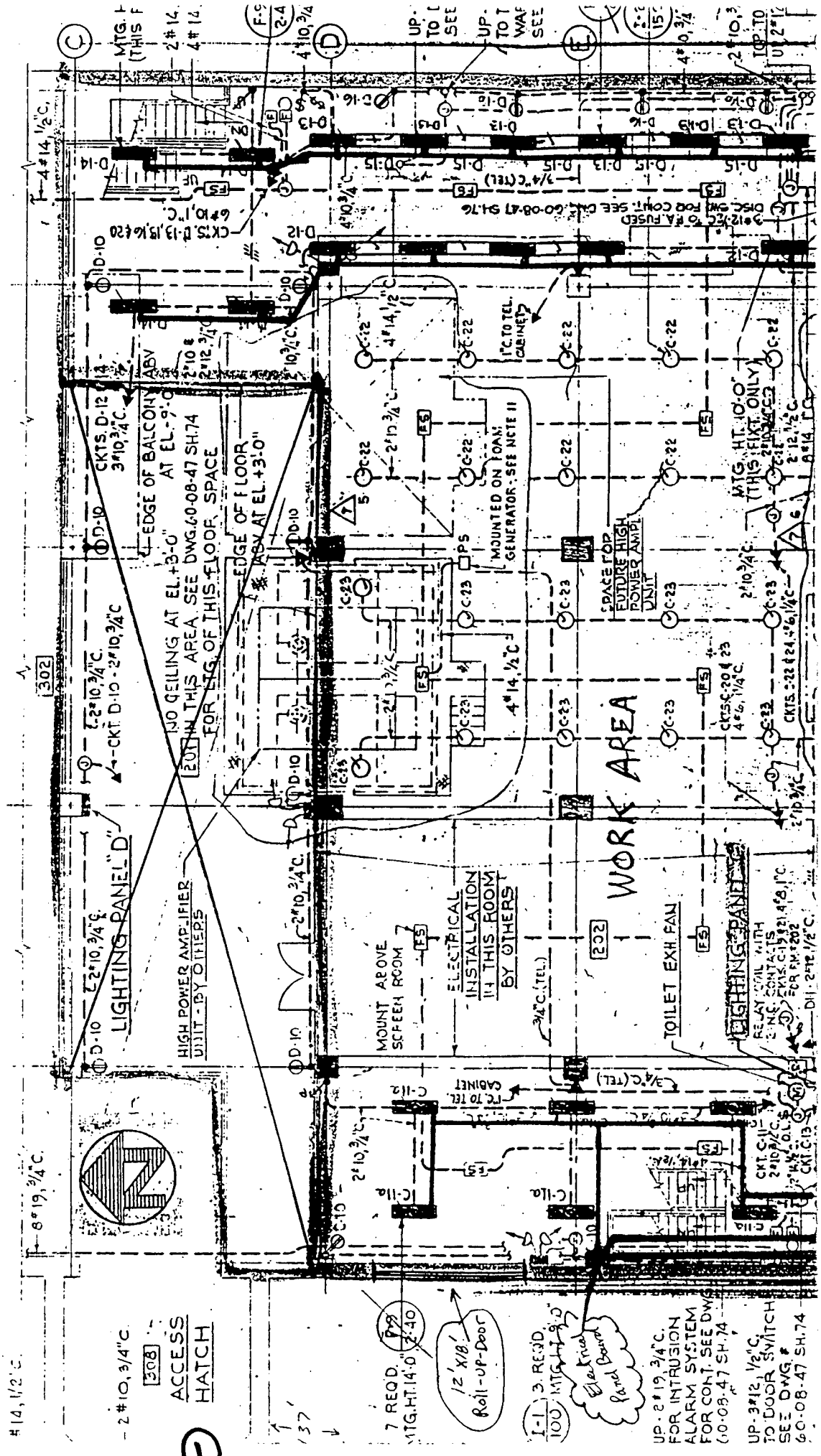
- 1.) Disconnect electrical power to the existing fluorescent lighting branch circuits.
- 2.) Replace the standard magnetic ballasts with low-wattage magnetic ballasts.
 - 22 - Basement
 - 34 - 1st Floor Office / Lounge Area
 - 23 - 1st Floor Maintenance / Work Area
 - 23 - 1st Floor Mezzanine Storage Area
 - 15 - 2nd Floor
- 3.) Replace the standard 40 watt lamps with low-wattage (34 watt) fluorescent lamps.
 - 44 - Basement
 - 68 - 1st Floor Office / Lounge Area
 - 46 - 1st Floor Maintenance / Work Area
 - 46 - 1st Floor Mezzanine Storage Area
 - 30 - 2nd Floor
- 4.) Install an electrical panel board for lighting branch circuits.
- 5.) Install lighting branch circuits and lighting switches.

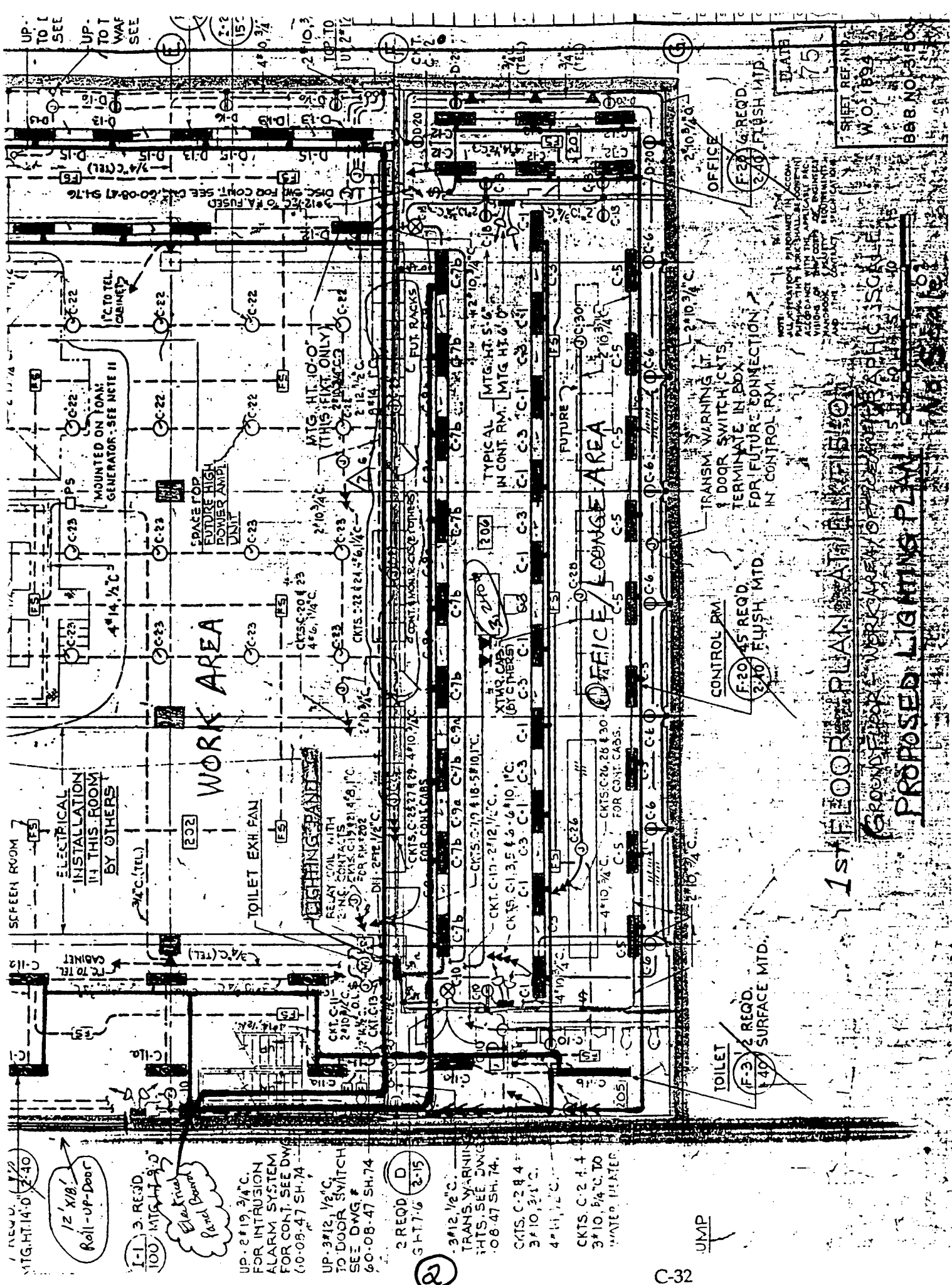
Bldg. Area	No. of Lighting Branch Circuits	Linear Feet of Conduit	No. of Lighting Switches
Basement	2	552	2
1st Flr - Office / Lounge	3	444	4
1st Flr - Work Area	2	337	2
1st Flr - Mezz. Storage	2	372	2
2nd Flr	1	283	2





2





NEW V. 12' X 18' Roll-up Door
 12' X 18' Roll-up Door
 12' X 18' Roll-up Door

I-1 3 REQD
 100' MTG. HT. 10' 3"
 Electrical Panel Board
 UP-2#19, 3/4" C.
 FOR INTRUSION
 ALARM SYSTEM
 FOR CONT. SEE DWG.
 60-08-47 SH. 74
 UP-3#12, 1/2" C.
 TO DOOR SWITCH
 SEE DWG. #
 60-08-47 SH. 74

2 REQD D
 3#7/8 2-15
 3#12, 1/2" C.
 TRANS. WARNING
 HTS. SEE DWG.
 60-47 SH. 74
 CKTS. C-28 4
 3#10, 3/4" C.
 4#11, 1/2" C.
 CKTS. C-24 4
 3#10, 3/4" C. TO
 WATER HEATER

UMP

1st FLOOR PLAN AT ELKELISION

GROUND FLOOR WORK AREA OF 22' X 10' 3" (15' X 10' 3" SCALE)

PROPOSED LIGHTING PLAN

NOTES:
 ALL INFORMATION FURNISHED IN CONNECTION WITH THIS PROJECT SHALL BE FOR THE USE OF THE APPLICANT ONLY. THE APPLICANT SHALL BE RESPONSIBLE FOR THE ACCURACY OF THE INFORMATION FURNISHED AND FOR THE PROTECTION OF THE INFORMATION FROM UNAUTHORIZED DISCLOSURE.

DATE 75
 SHEET REF. NO. W.O. 1894
 BAB NO. 3150



STORES

F-3 20 REQ'D.
1-40 MTG. HT. 8'-6"

STORES

F-3 17 REQ'D.
1-40 MTG. HT. 7'-0"

I-1 22 REQ'D.
100 MTG. HT. 9'-0"

INTRUSION ALARM
TERMINAL CABINET

8-19, 3/4" C.

2-19, 1/2" C.

EL. CABINET

6" W. x 60" H. x 10" D.

*K.O.S. IN BOTTOM

OR FUTURE

EXTENSION TO ALARM

WELL IN TUNNEL

CKTS. D-7, 9, 11 & 25

8-18, 1/4" C. TO

TUNNEL L.T.C. & RECEPTS

FOR CONT. SEE DCH

71-05-101 SH. 10

TUNNEL

(2) 4-19, 1/2" C.

TO INTRUSION

ALARM CONTACTS

& LACING

PER PERSONNEL ACCESS

(UTILITY TUNNEL)

4-14, 1/2" C.

D-15 REQ'D.

2-15 MTG. HT. 7'-6"

CKTS. D-4 & 8

4-10, 3/4" C.

CKTS. D-2, 4 & 18

2-10 & 3-12, 3/4" C.

CKTS. D-1, 3 & 5

4-10, 3/4" C.

CKTS. D-2, 4 & 18

2-10 & 3-12, 3/4" C.

CKTS. D-1, 3 & 5

4-10, 3/4" C.

CKTS. D-2, 4 & 18

2-10 & 3-12, 3/4" C.

CKTS. D-2, 4 & 18

2-10 & 3-12, 3/4" C.

CKTS. D-1, 3 & 5

4-10, 3/4" C.

CKTS. D-2, 4 & 18

2-10 & 3-12, 3/4" C.

CKTS. D-2, 4 & 18

2-10 & 3-12, 3/4" C.

CKTS. D-1, 3 & 5

4-10, 3/4" C.

CKTS. D-2, 4 & 18

2-10 & 3-12, 3/4" C.

1ST FLOOR PLAN AT ELEV. 9'-0" MEZANINE (LEVEL)

PROPOSED LIGHTING PLAN

No SCALE

